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MARTIN
MARIETTA
CORPORATION
DENVER DIVISION

VOYAGER
CAPSULE

PRELIMINARY DESIGN (Phase B)

Contract Number 952001 FINAL REPORT

VOLUME III SURFACE LABORATORY SYSTEM
Section II Preliminary Design for OSE

AUGUST 31, 1967

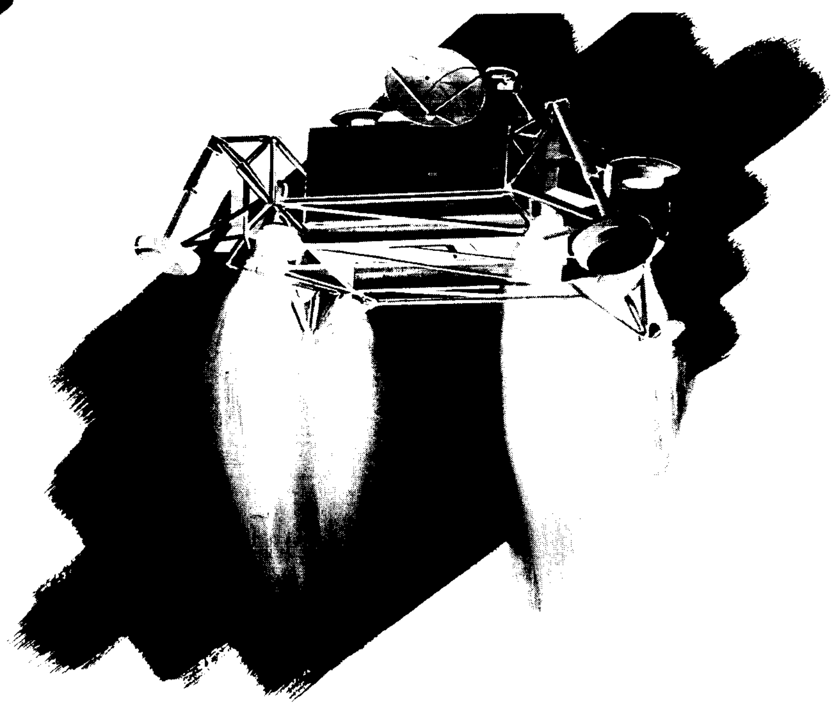
R. J. Kullas
Voyager Program Director

FOREWORD

This document is submitted in accordance with paragraph (a)(9) of Article 1, Statement of Work, to California Institute of Technology Contract No. 952001, which is a subcontract under NASA Contract NAS7-100. This document (→) is part of the Final Technical Report which consists of the following:

	Vol I	Summary
	CAPSULE BUS SYSTEM	
	Vol II, Section I	Capsule Bus
	Vol II, Section II	Preliminary Design for OSE
	Vol II, Section III	Implementation Plan
	Vol II, Section IV	Test Program
	SURFACE LABORATORY SYSTEM	
	Vol III, Section I	Surface Laboratory
→	Vol III, Section II	Preliminary Design for OSE
	Vol III, Section III	Implementation Plan
	Vol III, Section IV	Test Program
	ENTRY SCIENCE PACKAGE	
	Vol IV, Section I	Entry Science Package
	Vol IV, Section II	Preliminary Design for OSE
	Vol IV, Section III	Implementation Plan
	Vol IV, Section IV	Test Program
	Vol IV, Section V	Entry Science Package Interfaces
	Vol V	Interface Descriptions
	*Vol VI	RTG Report
	*Vol VII	A Flight Capsule with RTG for 1973

*Limited distribution of Vol VI and VII has been made as directed by JPL.



MARTIN MARIETTA CORPORATION

DENVER DIVISION

PREFACE

This volume of the Martin Marietta Corporation's Voyager Capsule Systems Final Report provides the results of the Surface Laboratory System preliminary design studies. In the performance of this Phase B study effort, Martin Marietta was assisted by RCA Astro-Electronics Division in the communications subsystem area, and Bendix Aerospace Division in the science subsystem area who also provided overall general assistance in Surface Laboratory design.

This volume consists of four sections: Section I, Surface Laboratory; Section II, Preliminary Design for OSE; Section III, Implementation Plan; and Section IV, Test Program.

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1. GENERAL REQUIREMENTS AND CONCEPTS

This section describes the requirements and conceptual implementation of the Operational Support Equipment (OSE) and Mission-Dependent Equipment (MDE) for the Surface Laboratory (S/L) portion of the Voyager Capsule Bus System. Descriptions for OSE include Subsystem OSE, Systems Test Complex, Launch Complex Equipment and Assembly, Handling, and Shipping Equipment.

Requirements and constraints specified in the following JPL/NASA documents provide the basis for OSE and MDE definitions:

1) SE002BB001-1B21 - Performance and Design Requirements for the 1973 Voyager Mission, General Specification for, dated 1 January 1967
2) SE003BB002-2A21 - Voyager Capsule Systems Constraints and Requirements Document, dated June 1967
3) EPD No. 283 (Rev 2) Planned Capabilities of the DSN for Voyager 1973.

In addition to these documented requirements, the flight subsystem configurations described in Section I of this document and integrated test requirements and supporting analyses and trade studies performed during the Phase B contract, provide further requirements for the OSE and MDE descriptions in this section.

1.1 OSE/MDE Concepts

Flexibility, commonality, standardization, Subsystem OSE and System Test Complex use of computers are some of the significant features incorporated in Voyager OSE designs because of Surface Laboratory requirements and constraints. These and other significant features are summarized below:

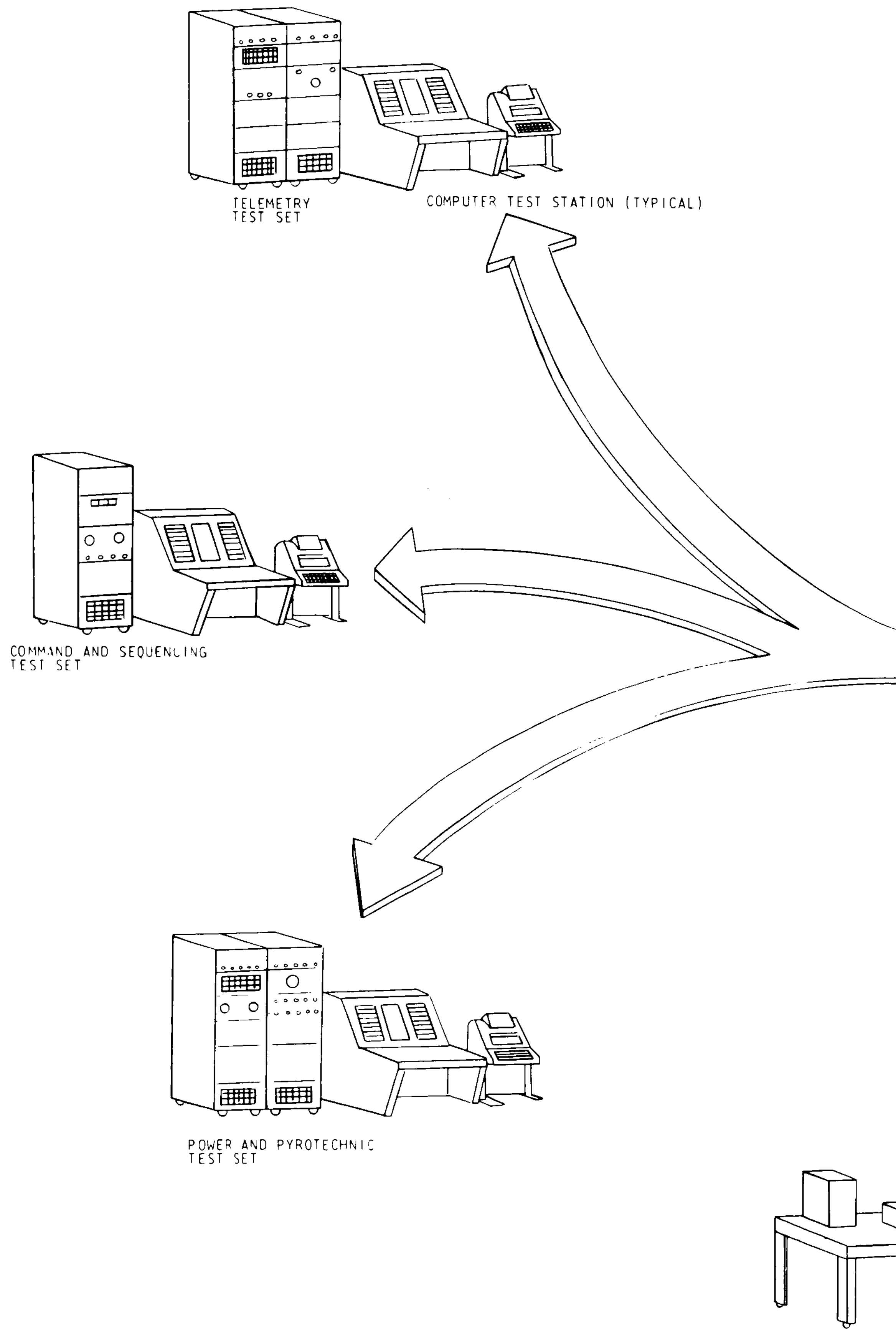
1) Flexibility is incorporated to permit support of all missions scheduled for the 1970 decade
2) Common equipment designs for Subsystem OSE, System Test Complex and Launch Complex Equipment are stressed to ensure correlation of data from one test to another. Common equipment is used extensively for stimuli and monitoring that equipment directly interfaces with flight equipment
3) Standardization is emphasized to permit maximum common use of equipment. Modular packaging techniques permit flexibility and efficiency of use
4) Reliability, maintainability, human engineering, and safety provisions are included to ensure system effectiveness
5) Cost effectiveness is achieved by time-sharing computer data systems between System Test Complexes, by standardized design and by using the System Test Complex to support Launch Complex Equipment requirements.

7) Transportability provisions are included to facilitate expeditious relocation and reinstallation of OSE. These provisions are particularly emphasized for Capsule vicinity OSE that is normally assigned to a flight article and remains dedicated to it throughout all system test phases
8) Simulation of interfaces is provided for all levels of testing to ensure complete and realistic testing
9) Self-test of OSE is provided to ensure that flight equipment is not damaged by improper sequencing or OSE failure
10) Computer use by both subsystem OSE and the System Test Complex is featured to permit early development of computer software programs, and maximum common use of software between subsystem OSE and the System Test Complex
11) Capsule vicinity OSE design is highly integrated for the System Test Complex and Launch Complex Equipment to minimize the amount of equipment that must be relocated. Unique portions of subsystem OSE are packaged in modules to permit their incorporation in the System Test Complex on a selective basis
12) MDE recommendations are based on the planned operational characteristics and capabilities of the Deep Space Network Mission-Independent Equipment so duplication of capability is avoided
13) MDE and MDS designs are proved by use in the System Test Complex.

1.2 Summary OSE Descriptions

1.2.1 Subsystem OSE

Subsystem OSE required to support flight subsystem and replacement-level testing is illustrated in Fig. 1-1. Subsystem test capability is provided by Subsystem OSE test sets operating under control of a general-purpose digital computer system. The subsystem OSE computer system consists of a computer central processor (compatible with the type selected for the System Test Complex), input/output equipment and control and display equipment. The computer system provides test sequence control, and acquisition, storage, processing and display of data for the various tests sets. The subsystem test sets include manual control, unique stimuli, monitoring and display equipment in addition to the standard computer-controlled stimuli and monitoring equipment. Standard computer test stations are permanently located at designated test areas and are used with the various test sets to perform flight subsystem testing. Testing is accomplished by the computer system and the subsystem test sets in real time and on a time-sharing basis between the various test stations. Brief descriptions of subsystem test sets are provided on page 1-5.


TELEMETRY TEST SET
COMPUTER TEST STATION (TYPICAL)
COMMAND AND SEQUENCING TEST SET
POWER AND PYROTECHNIC TEST SET

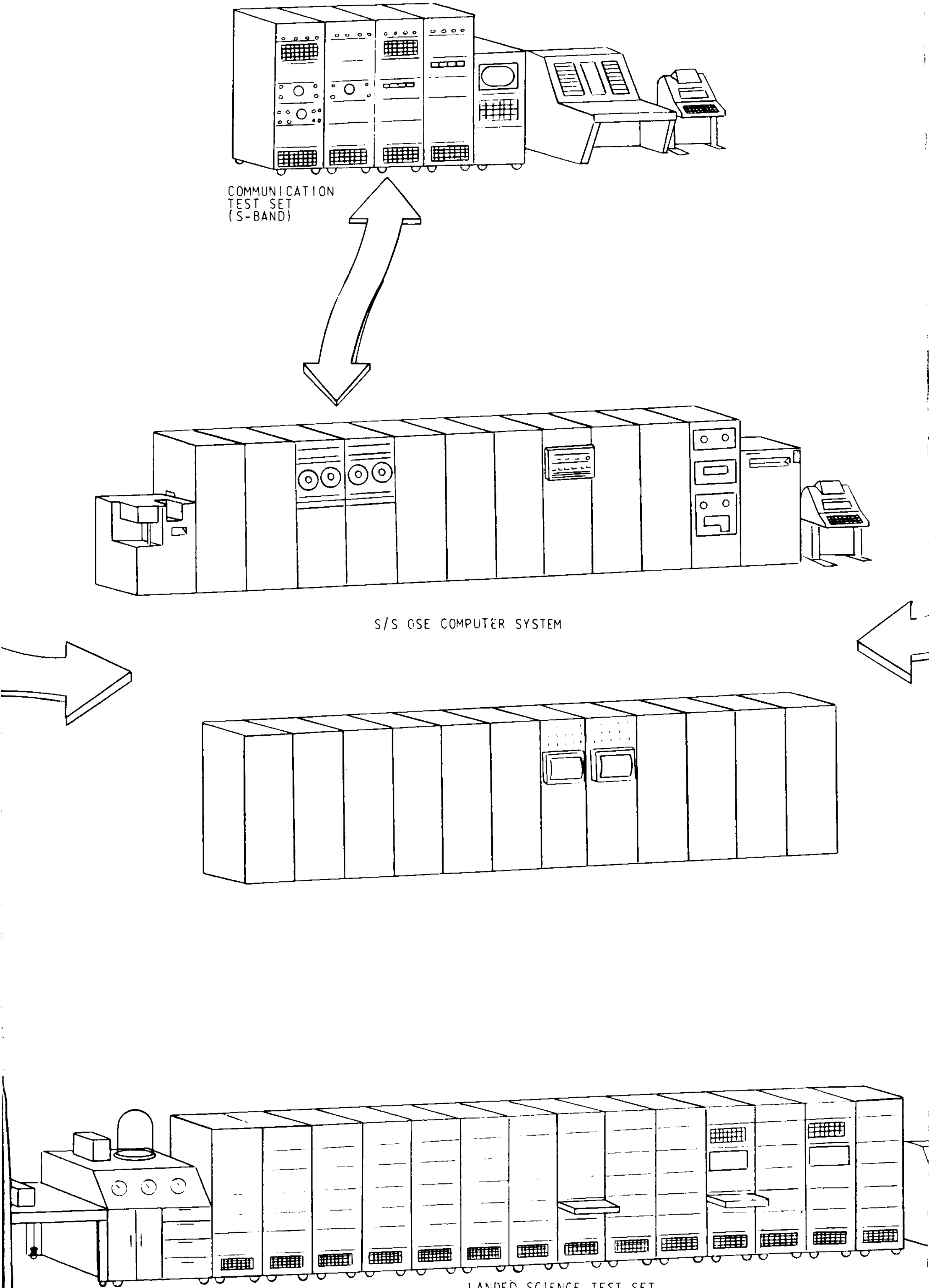


Fig. 1-1 Surface Laboratory Subsystem OSE

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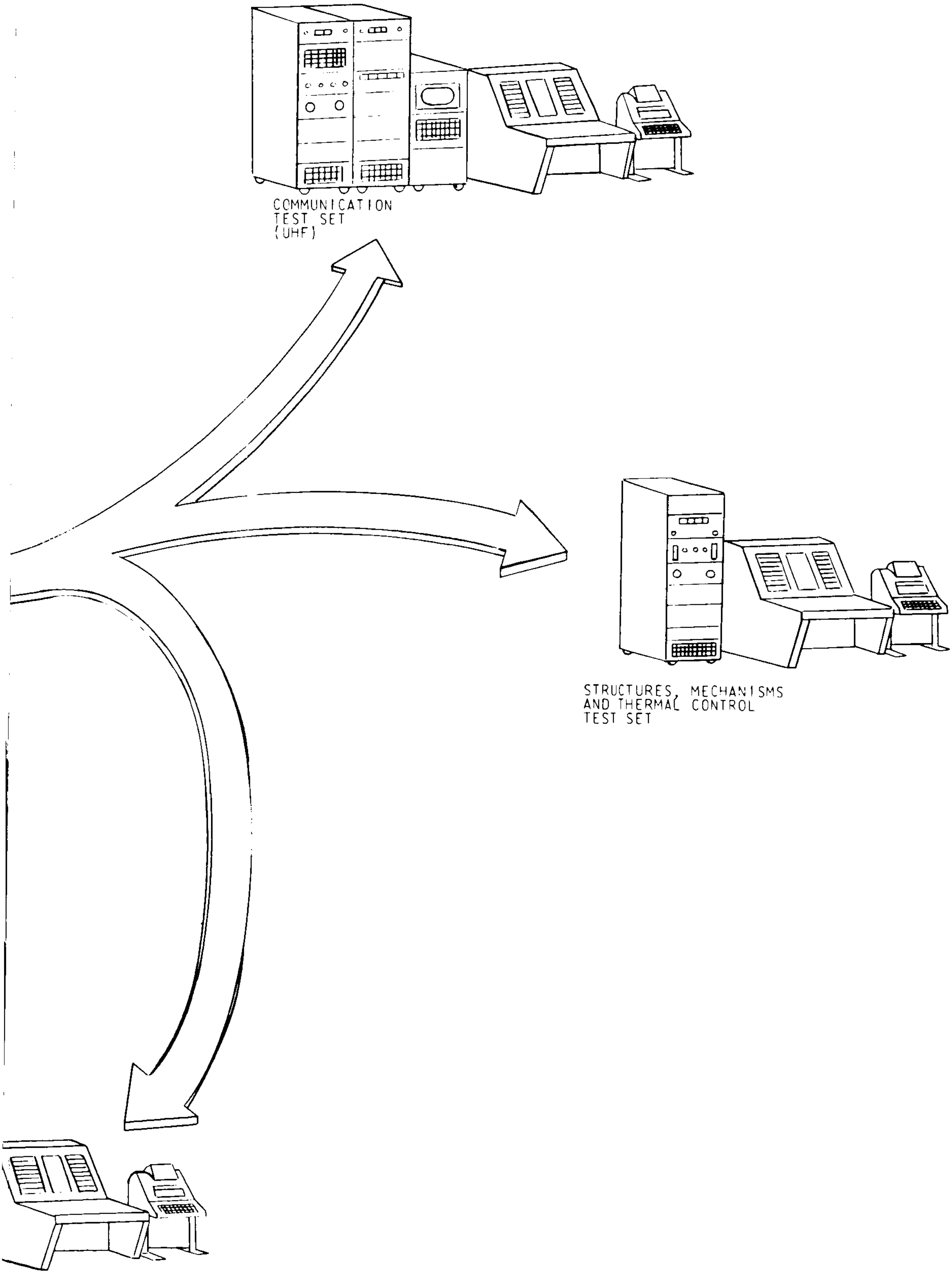

Power and Pyrotechnic Test Set - This set consists of two electronic equipment racks. One rack contains the computer data-acquisition equipment and built-in manual test equipment; the other contains power supplies, loads, command generator, and the computer interfacing equipment for test control. The set can test the Surface Laboratory power distribution, control and pyrotechnic circuits.

Telemetry Test Set - This set consists of two electronics equipment racks. One rack contains the computer control and data simulation equipment, the other contains the computer data monitor and built-in manual test equipment. Capability is provided for testing the Surface Laboratory telemetry subsystem encoders, transducer power supplies, signal conditioners, and the ground test data multiplexer.

Communications Test Set (UHF) - This set consists of two and one-half electronics equipment racks of standard commercial and special test equipment required to test the Surface Laboratory UHF communications equipment. Standard equipment is also included for computer control and data acquisition interfaces.

Communications Test Set (S-Band) - This set consists of four and one-half electronics racks of standard commercial and special test equipment required to test the Surface Laboratory S-band communications equipment. Standard equipment is also included for computer control and data acquisition interfaces.

Command and Sequencing Test Set - This set consists of one electronics equipment rack containing power supplies, conditioning and display equipment, and standard equipment for computer control and data acquisition interfaces. It provides the capability for testing the command and sequencing subsystem, which is contained in one replacement package.

Landed Science Test Set - Ten OSE sets are required for testing the landed science subsystem. Each of these sets is capable of independently testing its flight article and, as such, can be moved individually to computer test stations for parallel testing.

1) Visual Imaging Instrument Group - This test set consists of three electronics racks for reconstructing, displaying and recording TV pictures on film. It also includes capability for checking and aligning the flight instruments. It contains a test pattern generator, power supplies, cathode-ray tube display and associated control, conditioning and processing equipment.

2) Molecular Composition Instrument - This test set contains a mass spectrometer, leak detector, gas supplies, and associated electronics required for checkout of the gas composition instrument. The electronics and gas supplies are housed in three equipment racks. The mass spectrometer and leak detector are separately packaged in individual units.

3) Solids Composition Instrument - This test set comprises standard laboratory instruments, other electronics circuitry and a vacuum pump required for checkout of the soil composition instrument, in two equipment racks.

4) Solar Insolation Instrument - This test set contains an illuminator that provides radiation of known intensity and spectral characteristics for insolation instrument checkout. It is contained in one equipment rack and is used with a standard laboratory spectrometer, which is separately packaged.

5) Atmospheric Instrument - This test set contains a vacuum and thermal control unit and associated electonics separately packaged in one electronics rack for checkout of the atmospheric instruments.

6) Biological Analyzer - This test set shares the vacuum and thermal control unit for the atomospheric instrument and provides soil-sample simulation for flight-instrument checkout. It also includes necessary electronic test equipment separately packaged in one electronics rack and a small table for mounting the analyzer and soil-sample simulator.

7) Metabolism Detector - This test set includes a special vacuum chamber for simulation of the Martian environment and associated electronics separately packaged in one electronics rack. It provides flight-instrument checkout.

8) Science Data Subsystem - This test set provides for checkout of the science data subsystem. It consists of three electronics racks containing general-purpose electronic checkout equipment specially designed to interface with high-speed digital data.

9) Sample, Acquisition and Processing System - This test set provides for checkout of the sample acquisition and processing system. It contains general-purpose electronics separately packaged in one electronics rack and special equipment and materials to simulate the soil and surface conditions of Mars.

10) Landed Science Subsystem - This test set provides the ability to test the complete landed science subsystem. It consists of general-purpose

electronic equipment housed in three racks and one rack of special-purpose TV equipment. A sensor stimulus unit is also included and is separately packaged.

Structures, Mechanisms and Thermal Control Test Set - This set consists of one electronics rack containing power supplies, control displays, conditioning and standard computer-controlled stimuli and monitoring equipment. It provides for testing mechanisms and sensors (e.g., strain gages, thermocouples) that are part of the structures and mechanisms subsystem, and the thermal control subsystem heaters and thermostats.

1.2.2 System Test Complex (STC)

System Test Complexes required to support development, qualification, and acceptance testing of Flight Capsule Systems are illustrated in Fig. 1-2. Each STC is divided into the following functional equipment groups.

Control and Display - This group includes the various consoles and other equipment required for man-machine interface with the computer data system for test control and data display. The equipment is located in the control center and generally remains fixed at a test facility location.

Capsule-Vicinity OSE - This group includes all the computer controlled command, stimuli, and digital-data acquisition and conversion equipment that interfaces with the flight systems. It also includes any unique subsystem OSE equipment required for testing the flight system. This equipment is located in the vicinity of the flight system and generally moves with it from test area to test area.

Computer Data System - This group includes the general-purpose digital computer and its associated input/output and peripheral equipment. The equipment is located in the control center and generally remains fixed at a test facility location. It is shared with more than one set of control and display and capsule-vicinity OSE.

The Entry Science Packages are tested by test complexes that use a subsystem OSE computer system and Entry Science Package subsystem test sets. The Surface Laboratory Systems are tested by System Test Complexes at the Surface Laboratory contractor's facility. The Capsule Bus Systems are tested by System Test Complexes located at the Capsule Bus contractor's facility.

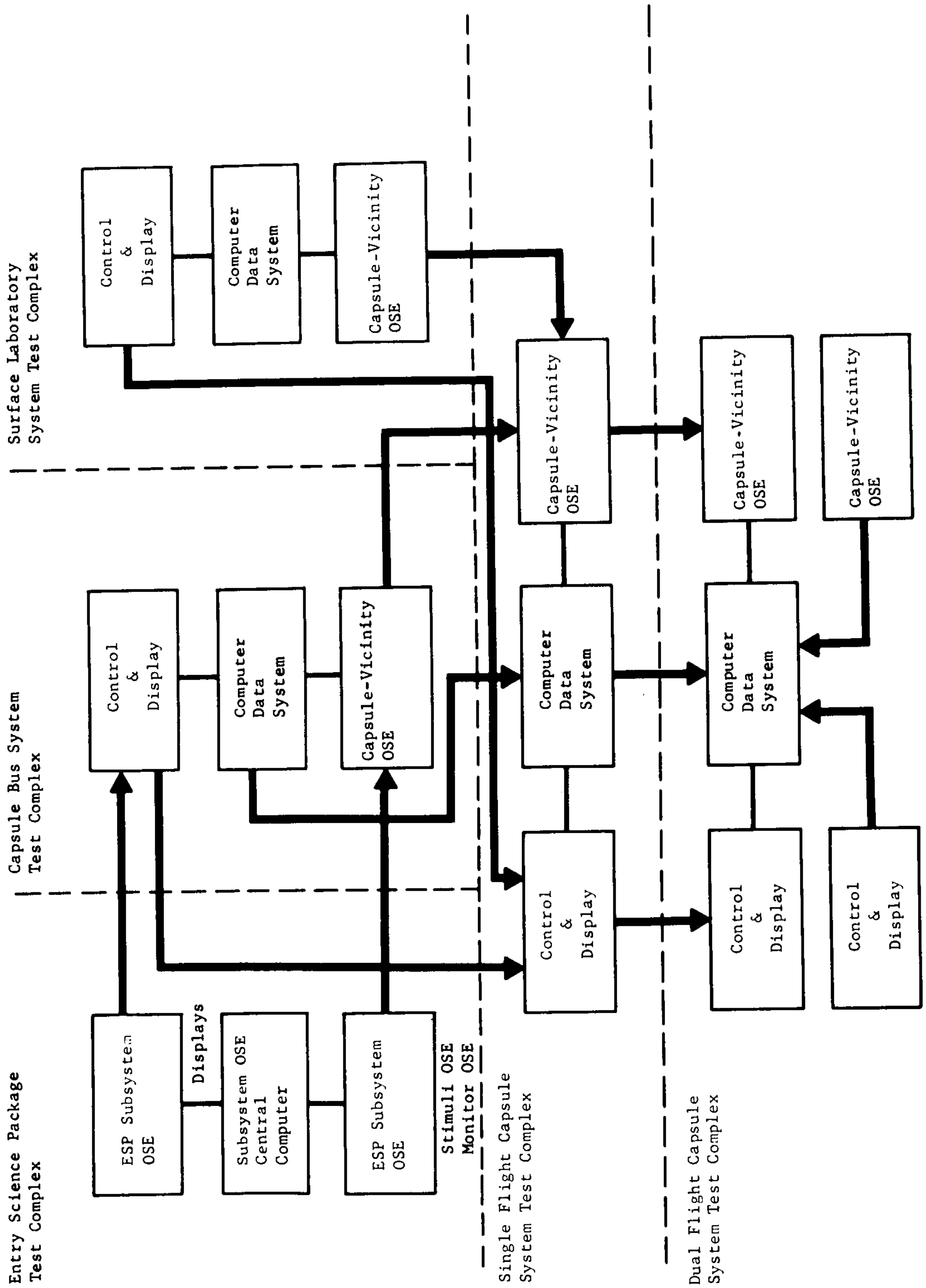

Fig. 1-2 Flight Capsule System Test Complex Configurations

After the Entry Science Package is tested by its test complex, it is integrated into the Capsule Bus. Selected portions of Entry Science Package subsystem OSE are included in the Capsule Bus System Test Complex to permit integrated testing of the Capsule Bus and Entry Science Package. The Capsule Bus computer data system is shared between the Capsule Bus and Entry Science Package for this configuration.

After Surface Laboratory System testing is completed by its System Test Complex, it is integrated with the Capsule Bus and Entry Science Package into a Flight Capsule configuration. Selected portions of Surface Laboratory Capsule-vicinity and control and display OSE are included in the Capsule Bus System Test Complex to permit testing the complete Flight Capsule. The Capsule Bus computer data system is shared with the Capsule Bus, Entry Science Package and Surface Laboratory for this System Test Complex configuration that provides a single Flight Capsule System test capability. Figure 1-3 illustrates a typical Flight Capsule System Test Complex.

The Capsule Bus computer data system is sized to handle two complete Flight Capsules. Therefore a "dual Flight Capsule System Test Complex" configuration is provided by the inclusion of another complete set of Capsule-vicinity and control and display OSE for the Entry Science Package, Capsule Bus and Surface Laboratory. This configuration permits real-time testing of two integrated Flight Capsules on a time-shared basis.

Two dual Flight Capsule System Test Complex configurations are provided for use at the Capsule Bus contractor's facilities to support production testing of the four Capsules required for the Voyager mission.

Two dual Flight Capsule System Test Complex configurations are provided for use at Kennedy Space Center to support prelaunch and launch test operations for the four Capsules. Each dual Flight Capsule System Test Complex configuration comprises a single computer data system and two sets of Capsule-vicinity and control and display OSE that are moved from the Capsule Bus contractor's facility. (The computer data systems remain at the Capsule Bus contractor's facility to support later missions.) These two System Test Complexes are initially used to support testing of the Flight Capsules before marriage with the Spacecraft. One of the dual Flight Capsule System Test Complexes is used to support later Planetary Vehicle tests. The other one is then available for continued support of the two spare Capsules, in addition to providing backup for Planetary Vehicle testing.

1.2.3 Launch Complex Equipment (LCE)

Launch Complex Equipment supports prelaunch and launch activities of Flight Capsule Systems at Launch Complex 39. The LCE configuration, shown in Fig. 1-4 uses the System Test Complex. Basically, it is a dual Flight Capsule System Test Complex configuration, augmented by A2A transmission lines and remote display and control equipment at the launch control center and launch pad.

The Surface Laboratory Launch Complex Equipment consists of the launch control center and mobile launcher equipment groups. The launch control center group consists of the Surface Laboratory test coordinator console. The mobile launcher equipment group consists of an emergency control and display unit and a signal conditioning unit.

Launch Complex Equipment checkout capability is based on command capability via the Spacecraft to the onboard sequencing equipment, telemetry data available through the Spacecraft data links, and hardwired safety controls and monitors available through the Planetary Vehicle umbilical. With the exception of safety control and monitoring, all Flight Capsule System testing is performed in cooperation with the Spacecraft contractor.

1.2.4 Summary Description of Mission-Dependent Equipment (MDE)

The overall implementation of MDE for support of Surface Laboratory mission operations is illustrated in Fig. 1-5. MDE consists of:

1) Data Processing MDE - This equipment accepts either normal (PN/PSK modulated) or emergency (M'ary encoded) telemetry data signals from the Mission-Independent Equipment (MIE) receiver, demodulates, and conditions the data stream for entry into the Telemetry and Command Processor (TCP). Equipment for M'ary demodulation/decoding includes filters, autocorrelators and controls. Equipment for PN/PSK demodulation includes demodulators, control and signal conditioning circuitry. Mission-dependent software is provided for use with the TCP.

2) Command MDE - This equipment converts command instructions issued from the MIE TCP into coded commands for application to the Deep Space Instrumentation Facility (DSIF) modulator. Command outputs from the DSIF transmitter are detected to enable verification. Backup capability is provided for manual generation of coded commands. Equipment includes buffers, controls, detectors and a code generator. Mission-dependent software is provided for use with the MDE and the TCP.

1-11

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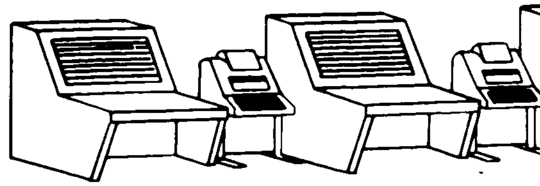

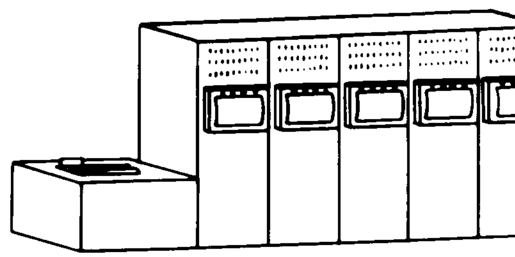

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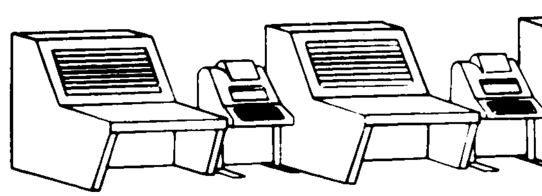

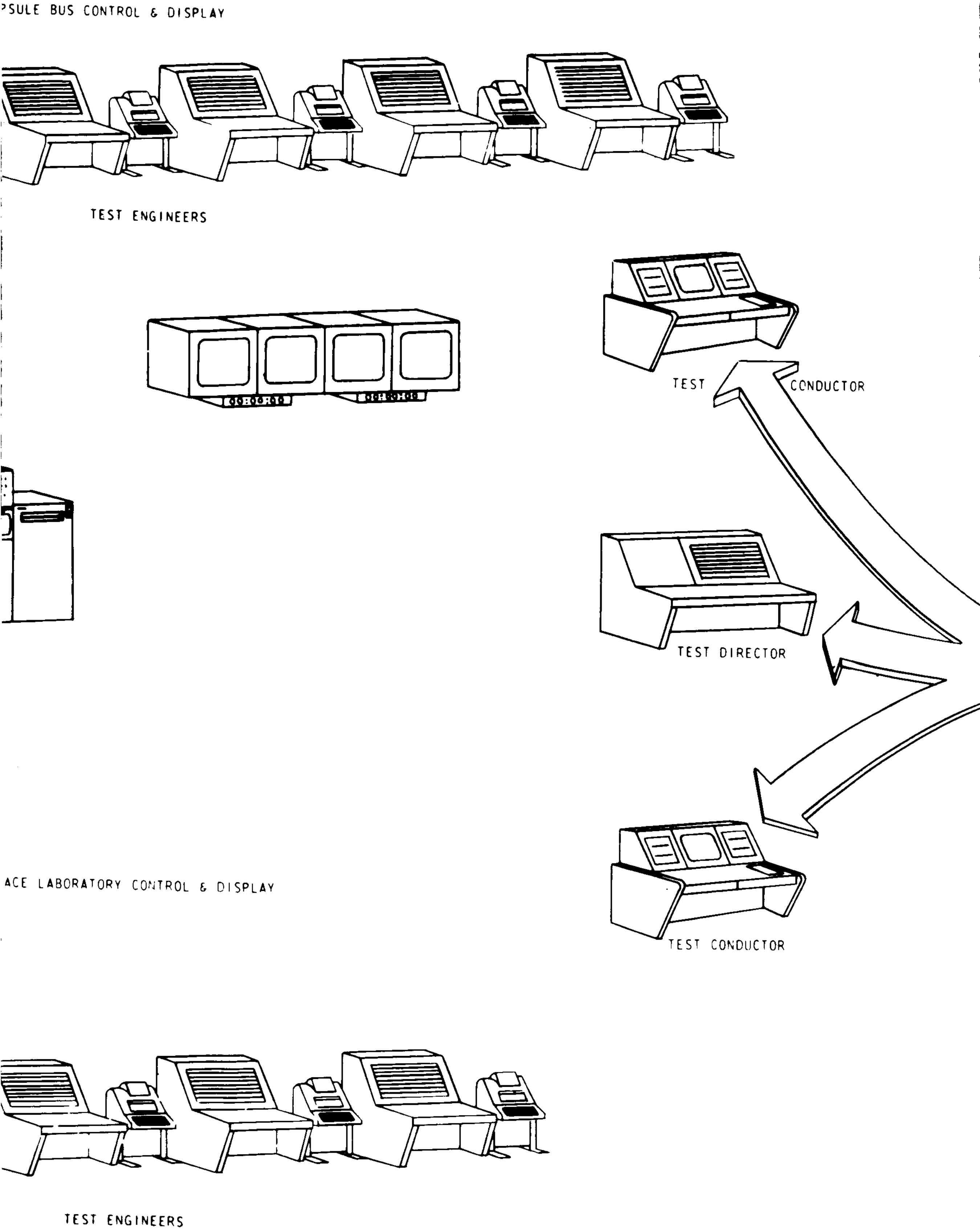
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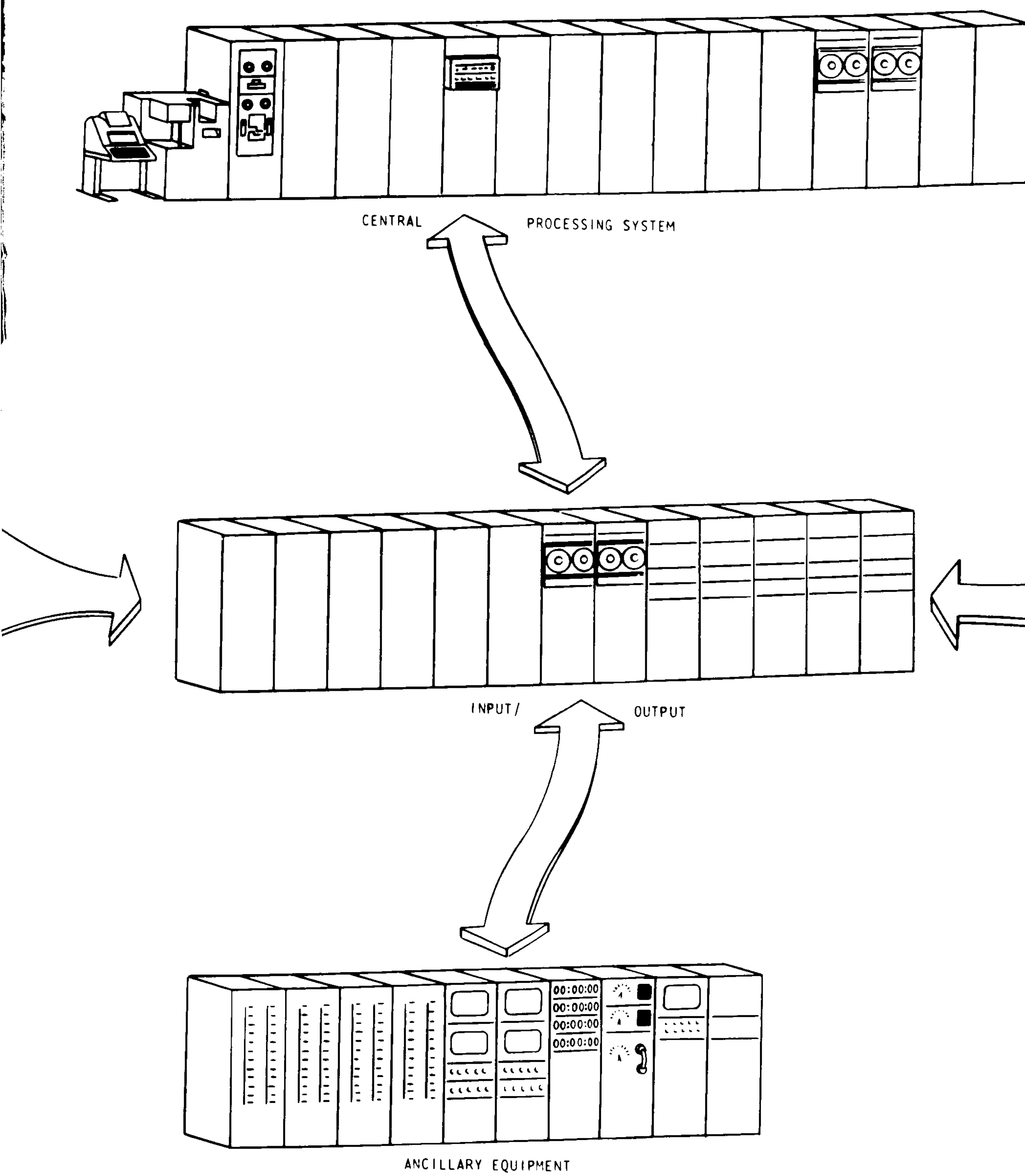
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ANCILLARY EQUIPMENT

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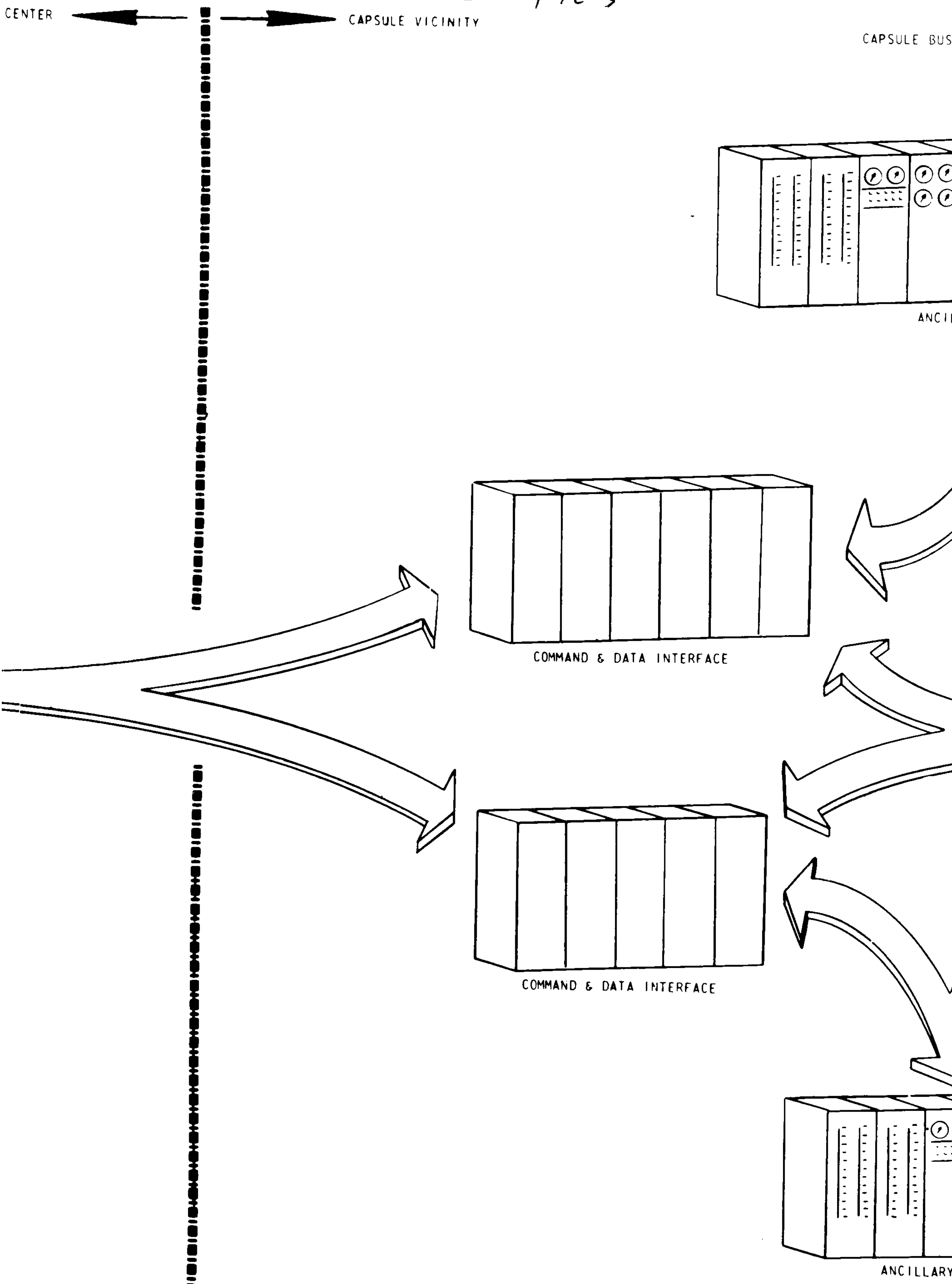
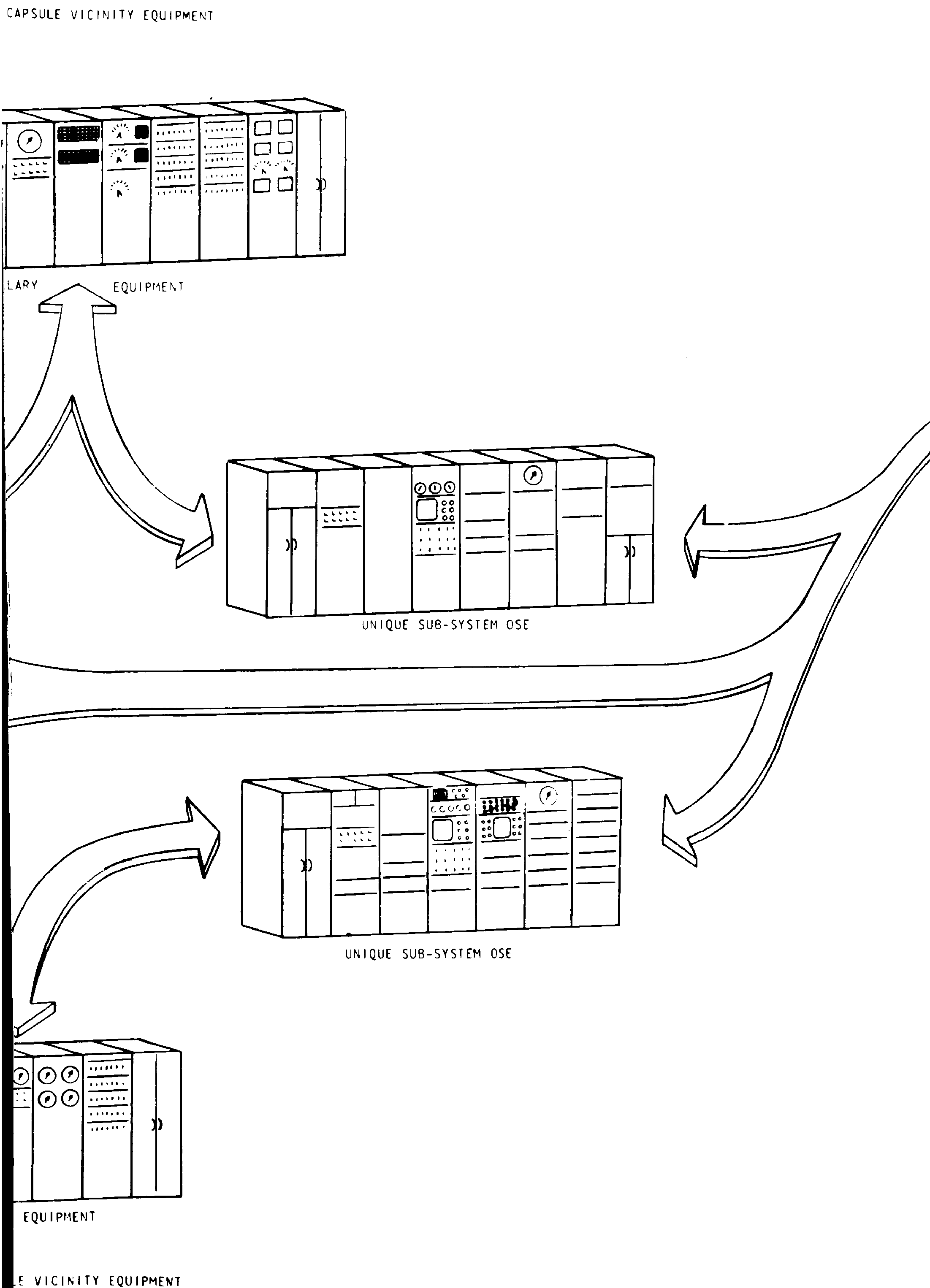


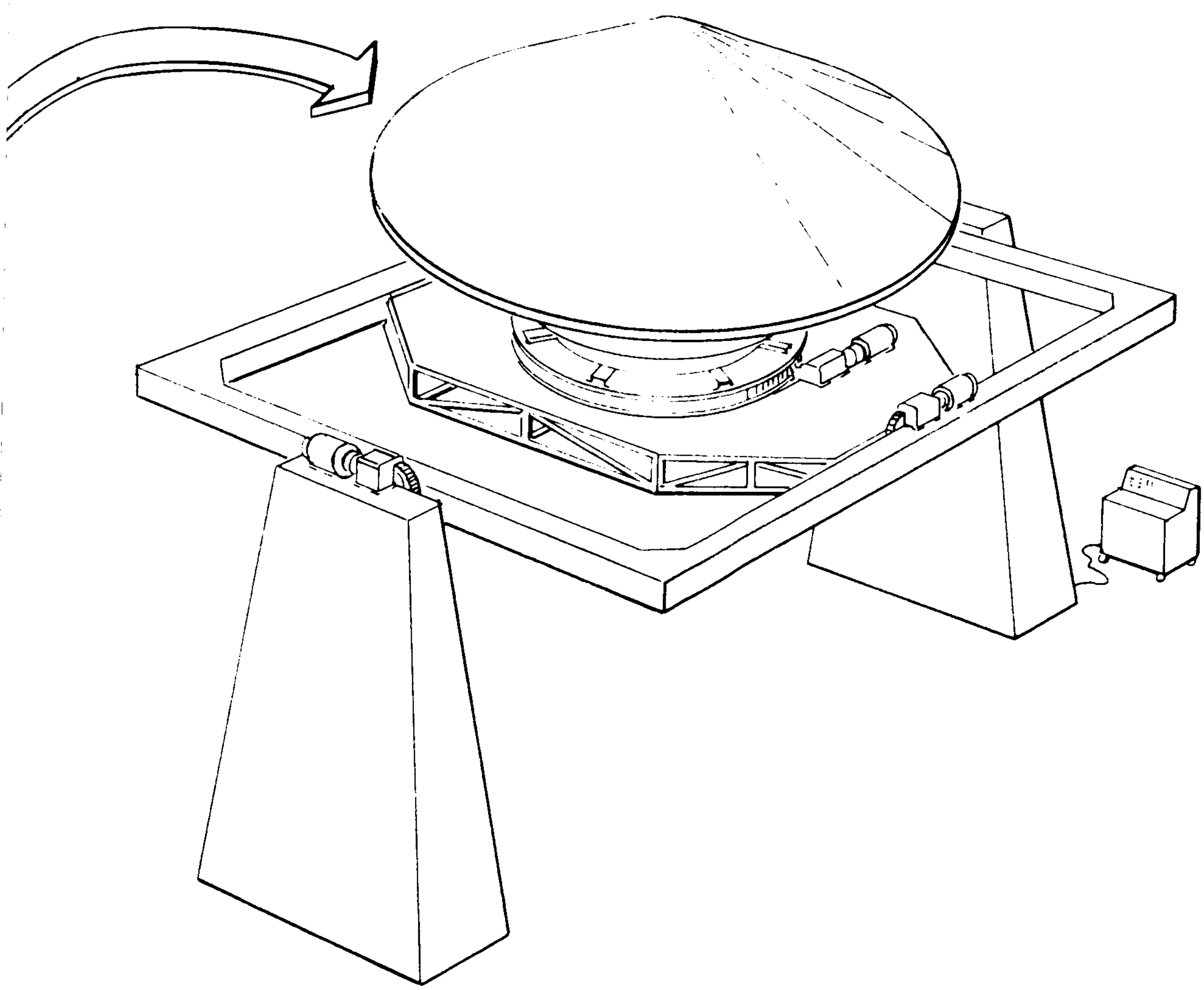
Fig. 1-3 Typical Flight Capsule System Test Complex

SURFACE LABORATORY CAPSU

1-12-4



CAPSULE VICINITY EQUIPMENT
LARY EQUIPMENT
UNIQUE SUB-SYSTEM OSE
UNIQUE SUB-SYSTEM OSE
EQUIPMENT
E VICINITY EQUIPMENT



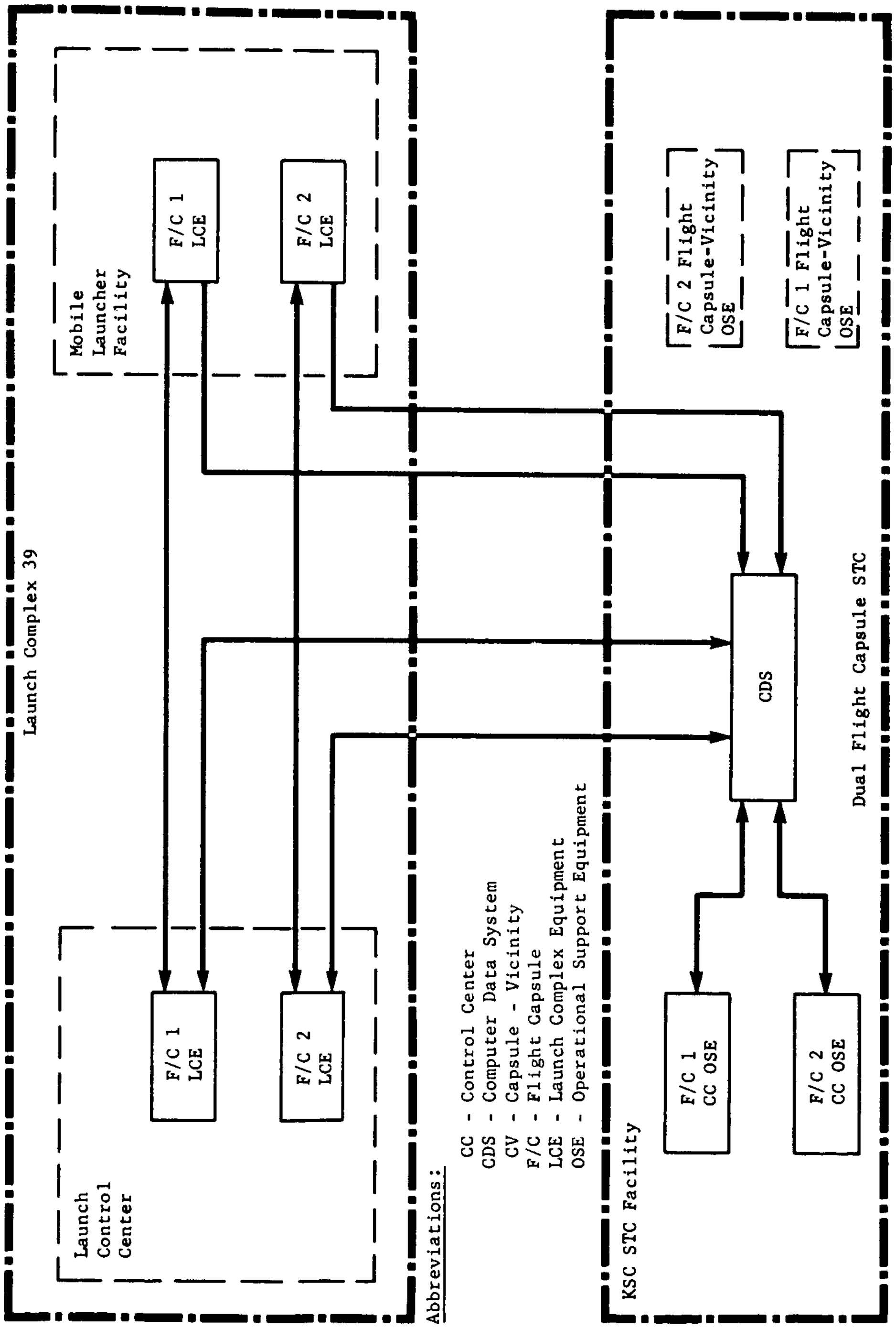


Fig. 1-4 Launch Complex Equipment

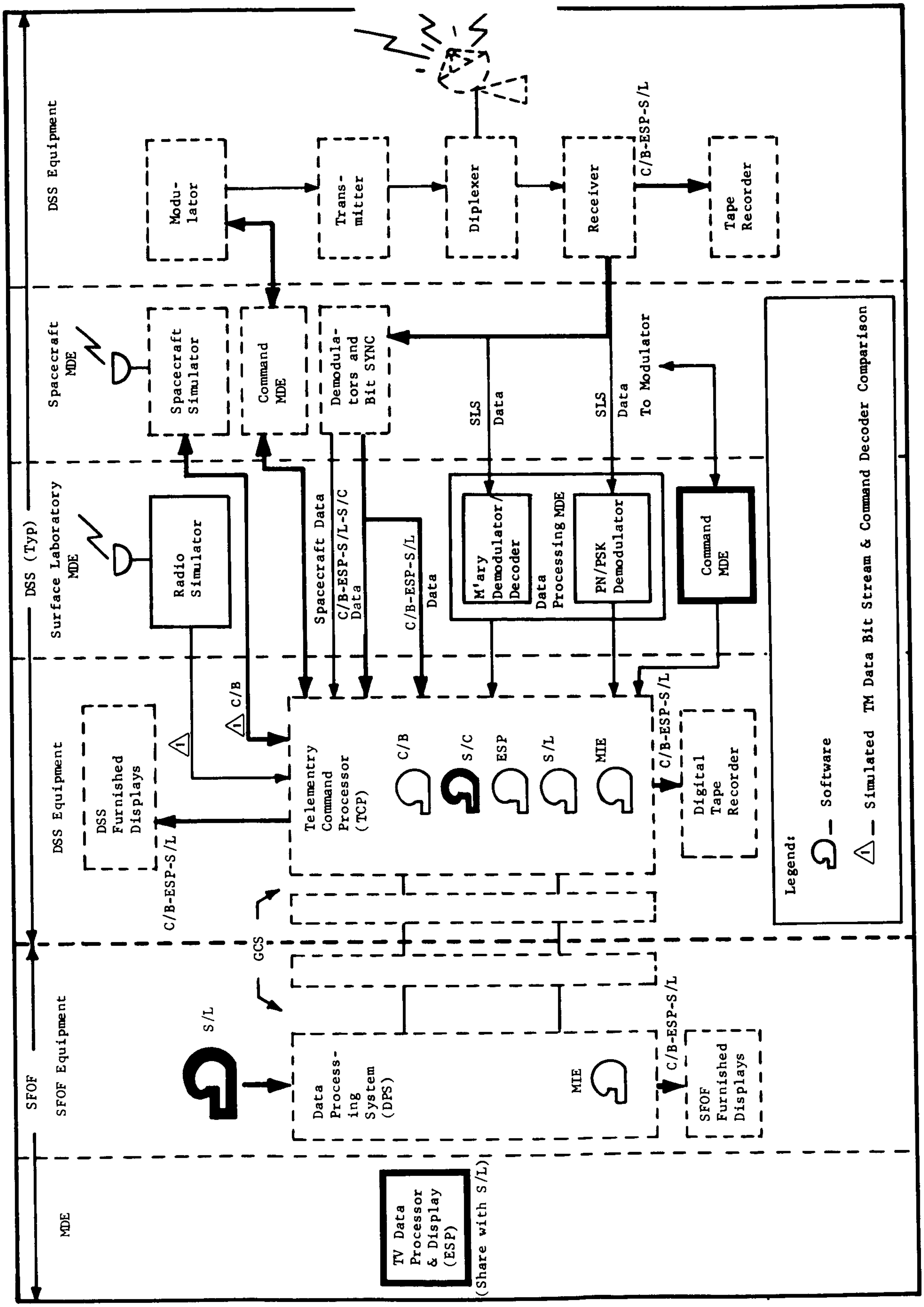


Fig. 1-5 Surface Laboratory MDE Implementation

3) Radio Simulator - This equipment provides for simulating the Surface Laboratory (S/L) radio command telemetry interfaces with the DSIF transmitter-receiver for checkout of the DSIF. It also provides a simulated IF output to permit independent checkout of S/L MDE. It contains an S-band transponder, diplexer, power supply, modulators, and controls.

4) TV MDE - This equipment consists of two electronics racks that provide for reconstructing TV pictures from video data stored on Space Flight Operations Facility (SFOF) magnetic tape. Pictures are displayed on a cathode-ray tube that is used as an exposure source for recording the data on film. A film processor is also included to provide negatives for photographic enlargement. The TV MDE unit provided by the Entry Science Package contractor is shared with the Surface Laboratory. Mission-dependent software is provided for use with the SFOF Data Processing System.

1.2.5 Summary Description of Assembly, Handling, and Shipping Equipment (AHSE)

The assembly handling and shipping equipment includes all items necessary to lift, hold, position, align, assemble, test, transport or store the Surface Laboratory or any of its components. The selected AHSE use is illustrated in Fig.1-6.

1.3 Requirements and Analysis

1.3.1 OSE System Analysis

During Phase B, an evaluation was made of the Voyager Program requirements to determine factors that have a significant effect on OSE selection and preliminary design. The following paragraphs identify the analyses performed to establish configuration selections.

1.3.1.1 Flight System Requirements

The primary requirement imposed on OSE is for support of the flight systems and subsystems during the development, qualification and operational phases of the program. Support includes tasks necessary to service, test, operate, monitor, maintain, and handle flight equipment safely and effectively. Flight system and subsystem requirements fall into two categories:

1) Those that impose functional requirements on OSE
2) Those that constrain OSE because of physical characteristics.

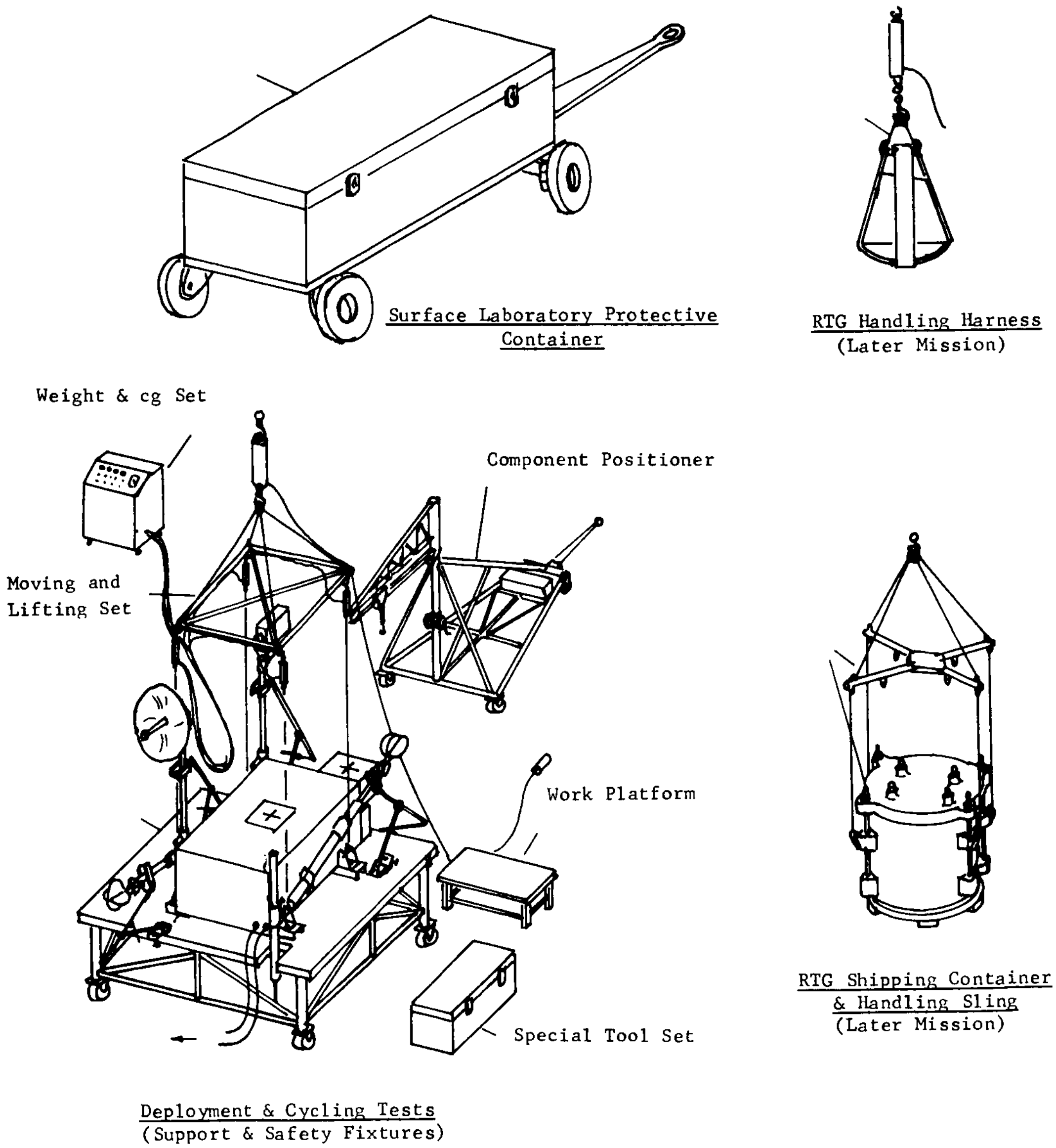


Fig. 1-6 Surface Laboratory Assembly, Handling & Shipping Equipment Use

Functional Requirements - Analysis of flight system requirements imposes the following general requirements on OSE.

1) OSE must support flight subsystem and system development, qualification and acceptance tests
2) OSE must provide ability to acquire, process, distribute and display all flight subsystem data links. This includes a variety of telemetry data links, each with variable formats and bit rates, and various analog, discrete, and digital signals available via direct access and umbilical connections
3) OSE must support isolation of malfunctions to the replacement assembly level
4) All alternative modes must be verified in simulated mission sequences
5) Integrated assembly tests are required to verify interfaces
6) Planetary Vehicle deep space station compatibility tests are required
7) Flight telemetry data must provide the primary data channels for monitoring of flight system performance. Direct access and umbilical monitoring is required where telemetry channels are lacking or sampling rates are insufficient to provide the necessary performance data
8) Because the flight sequencer provides the basic stimuli for flight system testing, OSE must include provisions for loading and verification of time-compressed simulated mission test sequences, special checkout routines, and actual flight mission programs
9) Monitors and safing controls are provided as hardlines for all critical functions that are hazardous to equipment or personnel.

Physical Constraints - The physical configuration of the Flight Capsule design imposes many constraints on the OSE. One of the most significant constraints is due to the requirement to encapsulate the entire Flight Capsule in a sterilization canister. This encapsulation severely restricts access to the flight subsystems by limiting the number of canister penetrations to those absolutely mandatory. Access provisions are further limited by the number of separation planes required for segmentation of the Flight Capsule during the various mission modes. Separation planes constrain access by limiting the number and types of functions carried across the interface because of reliability considerations.

Before encapsulation of the Flight Capsule, no significant constraints on access exist. However, some tests, such as thermal vacuum, require direct access restriction because of canister implacement and thermal isolation factors.

Access to the Flight Capsule is achieved in two ways -- direct access and umbilical access. Direct access for OSE interfaces is achieved through connectors provided by flight subsystems. In most instances, these connectors are lost upon installation of the canister. However, some direct access is provided for the more critical functions by routing them across the canister-adapter separation planes. This permits some degree of functional access even after encapsulation. The total post-encapsulation interface consequently consists of critical function monitors and controls, command hardline, telemetry hardline, multiplexer control and data lines, and ground power supply lines.

After post-sterilization testing umbilical provisions are used for Flight Capsule-Spacecraft marriage tests. Only critical hazard monitors and controls are routed via the Spacecraft to the umbilicals on the Planetary vehicle shroud. This is the total extent of the Flight Capsule umbilical access requirements with command, telemetry and power interfaces provided by the Spacecraft through umbilical interfaces and normal flight circuitry.

The considerations discussed above are directly responsible for the use of on-board sequencing and telemetry as the primary test mode and impose the following additional requirements on OSE:

1) Pre-encapsulation tests use direct access provisions for functional interfaces between OSE and flight subsystems
2) Post-encapsulation tests use direct access provisions and umbilicals available at the adapter
3) During and after Planetary Vehicle marriage tests, only umbilicals are used
4) RF radiation is limited to radiation at reduced power levels or radiation into dummy loads
5) No mechanisms are deployed while encapsulated
6) Nonreversible functions such as pyrotechnics are not actuated after encapsulation.

1.3.1.2 Test and Operations Flow

Analysis of the OSE test and operations support requirements is significant to to the functional and physical implementation of OSE. These requirements impose constraints on the physical and functional design of OSE configurations because support is required at a variety of facilities and at a number of different test levels. Figure 1-7 is a flow chart that illustrates OSE relationship to the various test facilities and test functions. The chart flows from left to right and shows the progression of activities from subassembly levels through final mission operation phases. The lower portion of the diagram presents a Surface Laboratory-Flight Capsule assembly flow with the test exposures for each assembly indicated under the appropriate test blocks. OSE relationships to the unit under test and to the test blocks are shown on the upper portion of the diagram.

Starting at the left of the diagram, the first operations encountered are the manufacturing assembly and test operations. Tests conducted in this area are accomplished using manufacturing test tools and are confined to the component-subassembly levels.

Components and subassemblies from the manufacturing area, or from outside vendors, are next assembled into assembly/replacement level packages. These packages are, wherever possible, subsystem peculiar. They undergo a series of tests at this level that are designed to ensure complete functional and environmental compatibility before assembly as a Surface Laboratory. Should there be more than one replacement level assembly per subsystem, each replacement level assembly is environmentally tested individually, with integrated subsystem functional tests conducted before and after the environmental tests. It is the task of the subsystem OSE to support these tests and the additional engineering development and evaluation tests.

As assembly proceeds to the Surface Laboratory level, assembly tests, ambient system tests, and environmental tests are conducted. After completion of Surface Laboratory testing, it is delivered to the Capsule Bus contractor's facility for integrated testing at the Flight Capsule level. Integrated Flight Capsule tests are conducted in several distinct areas. Assembly, ambient system, EMI, and vibration tests are conducted in the Spacecraft Assembly and Test Building. Space simulation thermal-vacuum tests are conducted in the Space Simulation Facility. The first flight systems through this flow are the Engineering and Proof Test Models (ETM and PTM). These vehicles provide development and qualification assurance testing to more stringent levels than required for flight systems. In addition to the flight system tests, OSE engineering evaluation tests are conducted using a flight system simulator. These tests verify OSE designs and flight system compatibility. In conjunction with these tests, and as a continuing follow-on activity, computer programing is developed and verified for the STC computer. The above activities are supported by System Test Complexes.

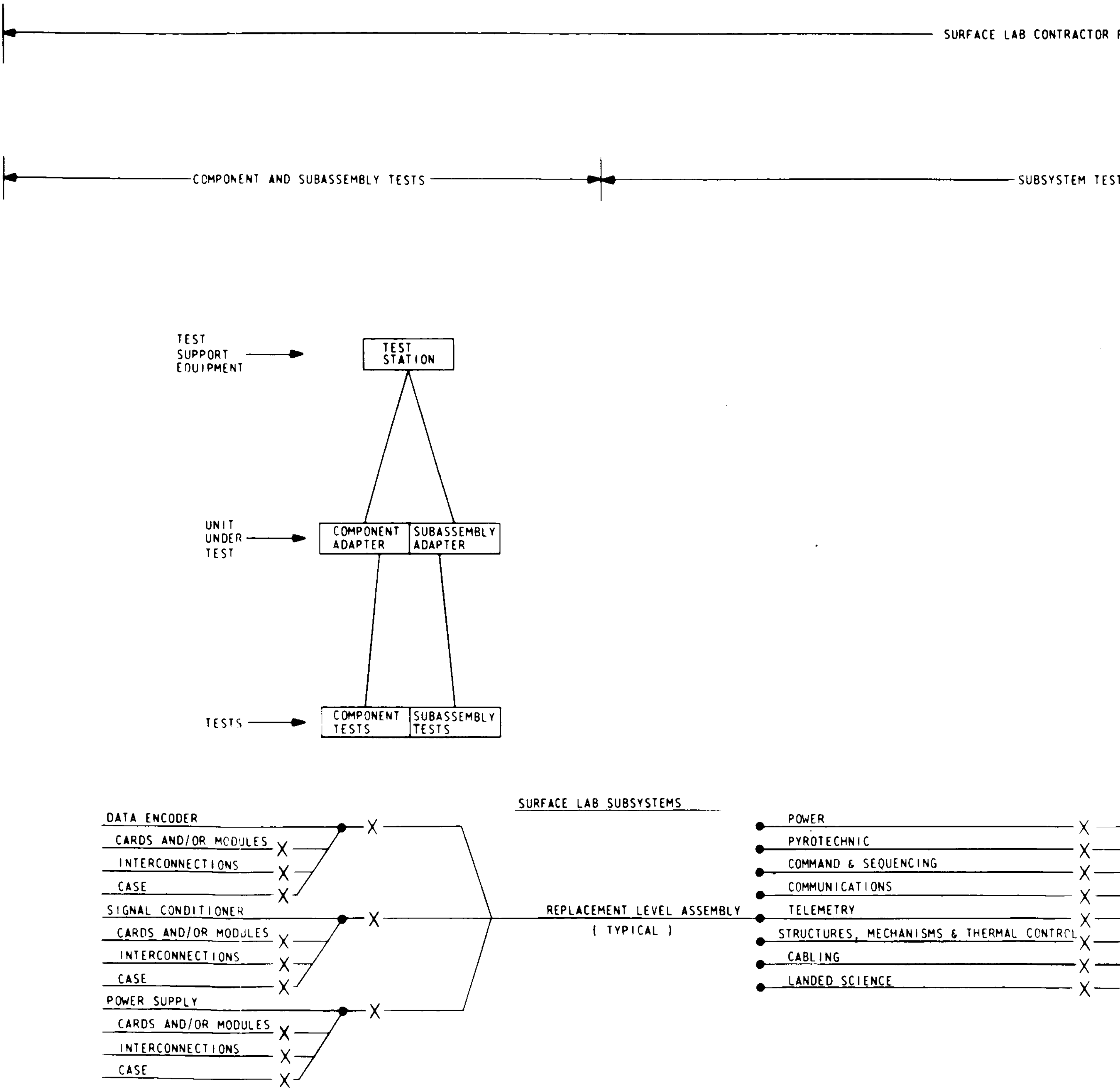
After completion of Denver ETM and PTM tests, these vehicles are transported to an integration facility for Planetary Vehicle compatibility tests with the Spacecraft System. These tests are also supported by System Test Complexes.

After completion of Denver test activities, Flight Capsule Systems are shipped to Kennedy Space Center (KSC) for prelaunch operations. These operations include encapsulation, sterilization and Planetary Vehicle marriage and are also supported with System Test Complexes. These test activities also include open-loop RF radiation tests to ensure compatibility between Planetary Vehicle Communication Systems and DSIF-71 and verify compatibility with the Deep Space Net.

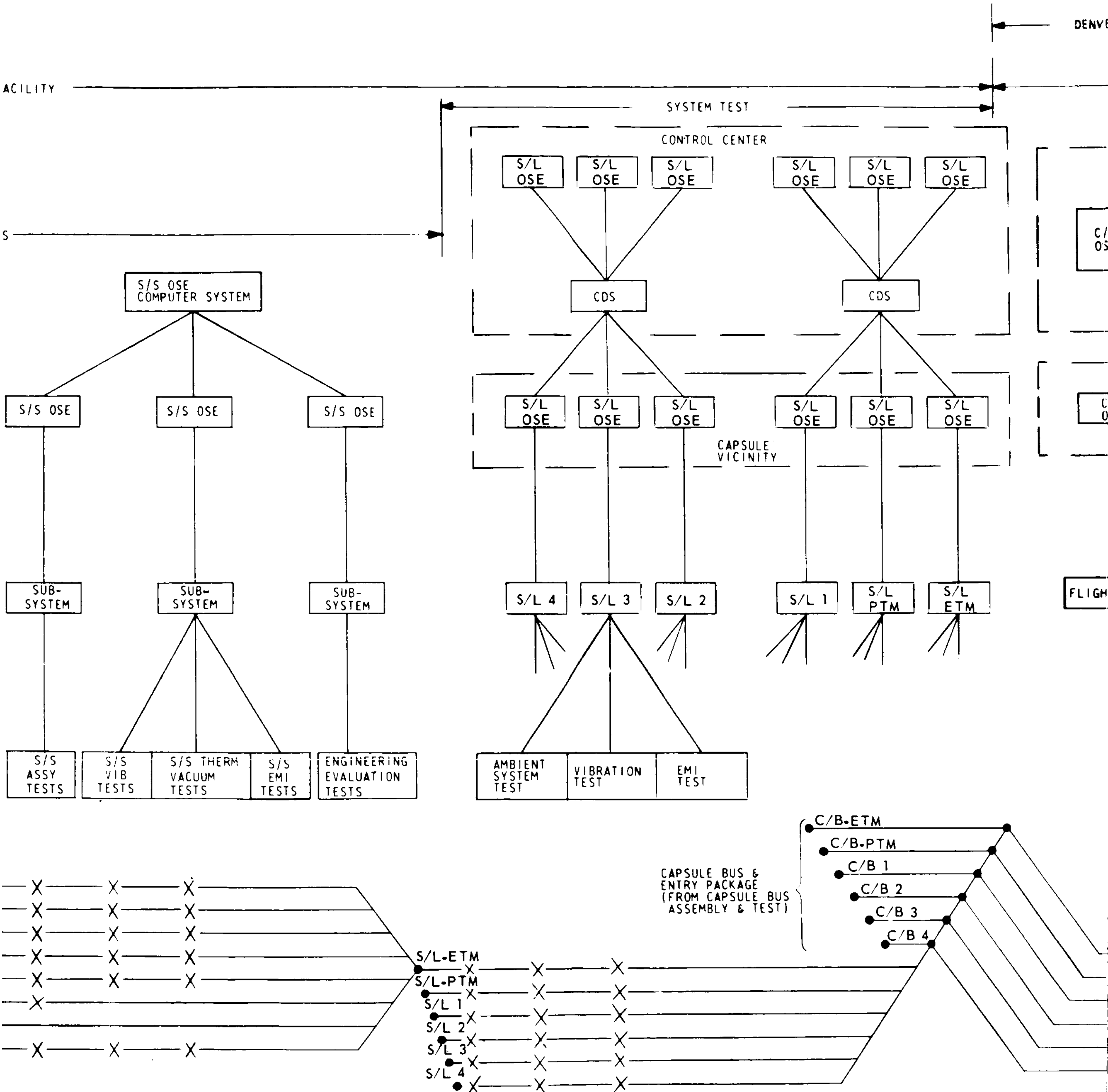
The final portion of the diagram portrays overall relationships between the Flight Systems and the ground monitoring facilities. These facilities provide command, tracking and data acquisition services for mission operations. The Deep Space Stations (DSS) provide the RF communication links with the Flight Systems while mission control is exercised from the Space Flight Operations Facility (SFOF). The Ground Communication System (GCS) provides the communication channels to link these facilities together on a common net. MDE is supplied, if required, to supplement MIE capabilities existing at these facilities to satisfy the Voyager mission-peculiar functions.

The test and operations flow imposes the following requirements on OSE:

1) S/S OSE is required to support all development and qualification tests for the flight subsystems. To perform this task, the subsystem OSE must be designed with sufficient versatility and flexibility to accomplish:
   a) Flight acceptance testing of replacement level subsystem assemblies
   b) Flight acceptance testing of assembled subsystems
   c) Development and qualification (type assurance) testing at each of the above levels
   d) Testing at various locations. This requires that OSE be capable of being readily relocated from test area to test area
2) System Test Complexes are required to support system testing at the S/L contractor's facility, the C/B contractor's facility, at KSC and at other special test locations. To accomplish this, STC design must include provisions for:

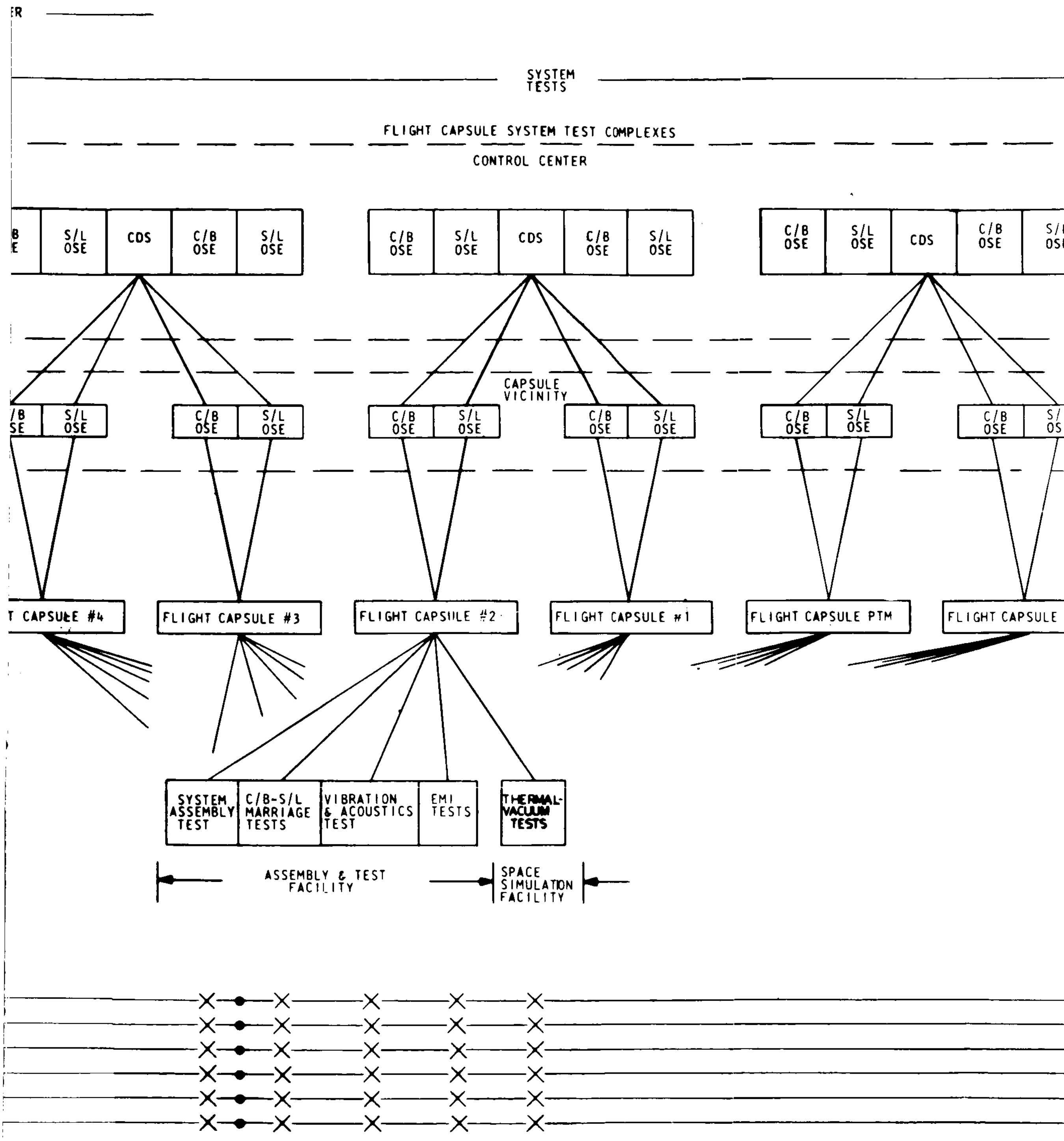

SURFACE LAB CONTRACTOR F
COMPONENT AND SUBASSEMBLY TESTS
SUBSYSTEM TEST
TEST SUPPORT EQUIPMENT
TEST STATION
UNIT UNDER TEST
COMPONENT ADAPTER
SUBASSEMBLY ADAPTER
TESTS
COMPONENT TESTS
SUBASSEMBLY TESTS
SURFACE LAB SUBSYSTEMS
DATA ENCODER
CARDS AND/OR MODULES
INTERCONNECTIONS
CASE
SIGNAL CONDITIONER
CARDS AND/OR MODULES
INTERCONNECTIONS
CASE
POWER SUPPLY
CARDS AND/OR MODULES
INTERCONNECTIONS
CASE
REPLACEMENT LEVEL ASSEMBLY
(TYPICAL)
POWER
PYROTECHNIC
COMMAND & SEQUENCING
COMMUNICATIONS
TELEMETRY
STRUCTURES, MECHANISMS & THERMAL CONTROL
CABLING
LANDED SCIENCE

1-22-1



DENVE
ACILITY
SYSTEM TEST
CONTROL CENTER
S/L OSE
CDS
S/S OSE COMPUTER SYSTEM
S/S OSE
CAPSULE VICINITY
SUB-SYSTEM
S/L 4
S/L 3
S/L 2
S/L 1
S/L PTM
S/L ETM
FLIGH
S/S ASSY TESTS
S/S VIB TESTS
S/S THERM VACUUM TESTS
S/S EMI TESTS
ENGINEERING EVALUATION TESTS
AMBIENT SYSTEM TEST
VIBRATION TEST
EMI TEST
C/B-ETM
C/B-PTM
C/B 1
C/B 2
C/B 3
C/B 4
CAPSULE BUS & ENTRY PACKAGE (FROM CAPSULE BUS ASSEMBLY & TEST)
S/L-ETM
S/L-PTM

1-22-2



ER
SYSTEM TESTS
FLIGHT CAPSULE SYSTEM TEST COMPLEXES
CONTROL CENTER
S/L OSE
CDS
C/B OSE
CAPSULE VICINITY
T CAPSULE #4
FLIGHT CAPSULE #3
FLIGHT CAPSULE #2
FLIGHT CAPSULE #1
FLIGHT CAPSULE PTM
FLIGHT CAPSULE
SYSTEM ASSEMBLY TEST
C/B-S/L MARRIAGE TESTS
VIBRATION & ACOUSTICS TEST
EMI TESTS
THERMAL-VACUUM TESTS
ASSEMBLY & TEST FACILITY
SPACE SIMULATION FACILITY

1-22-3

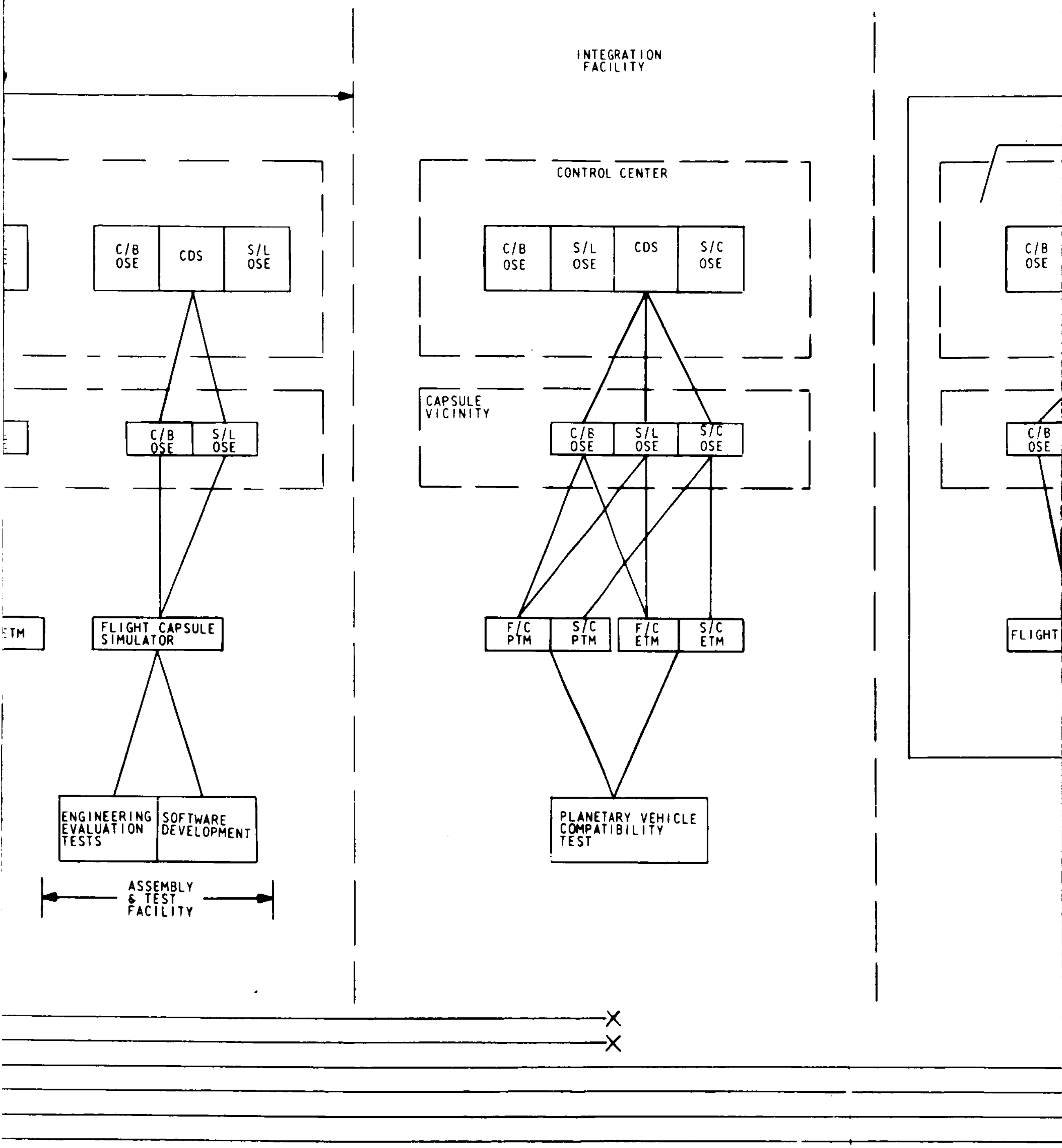
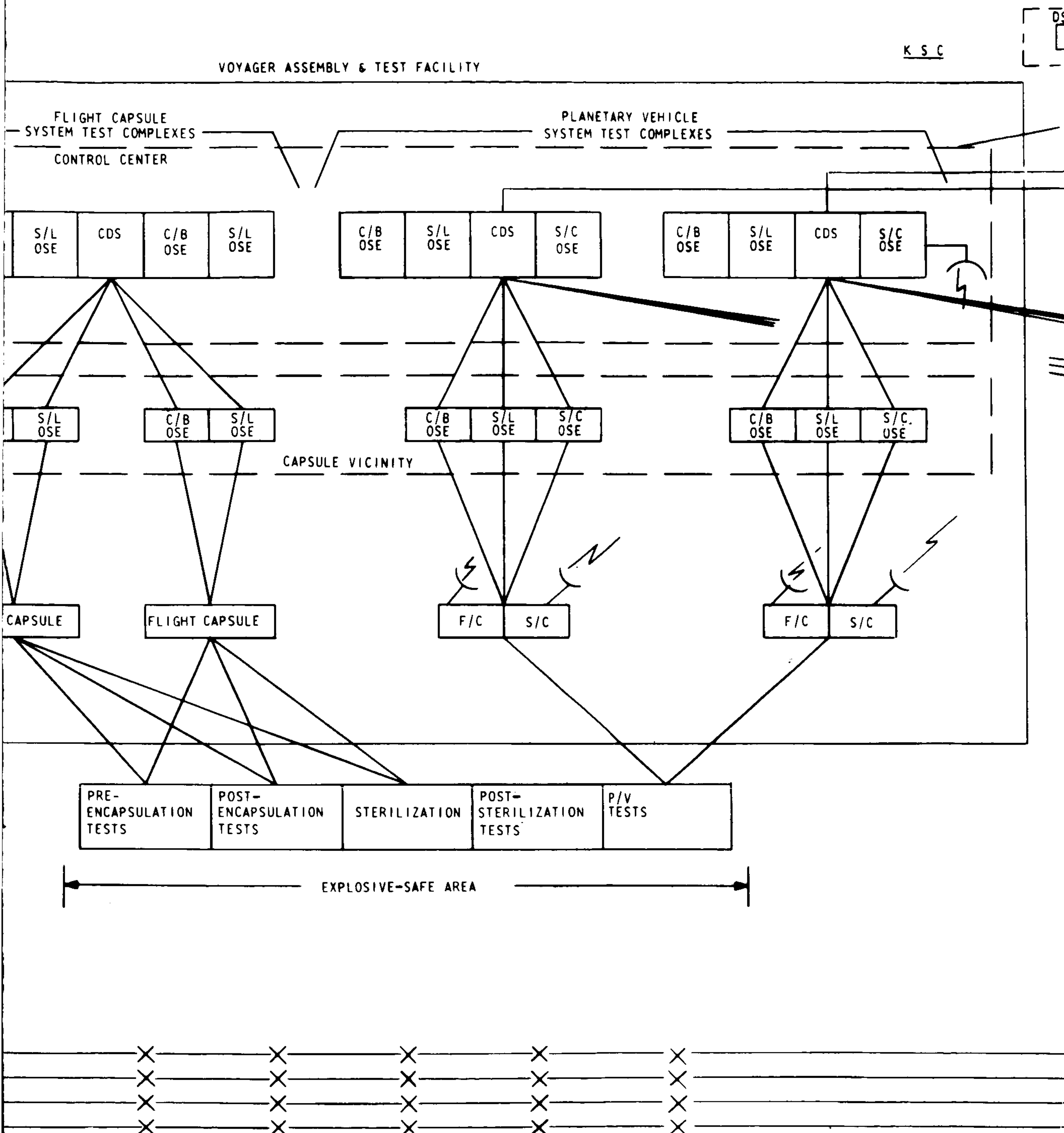


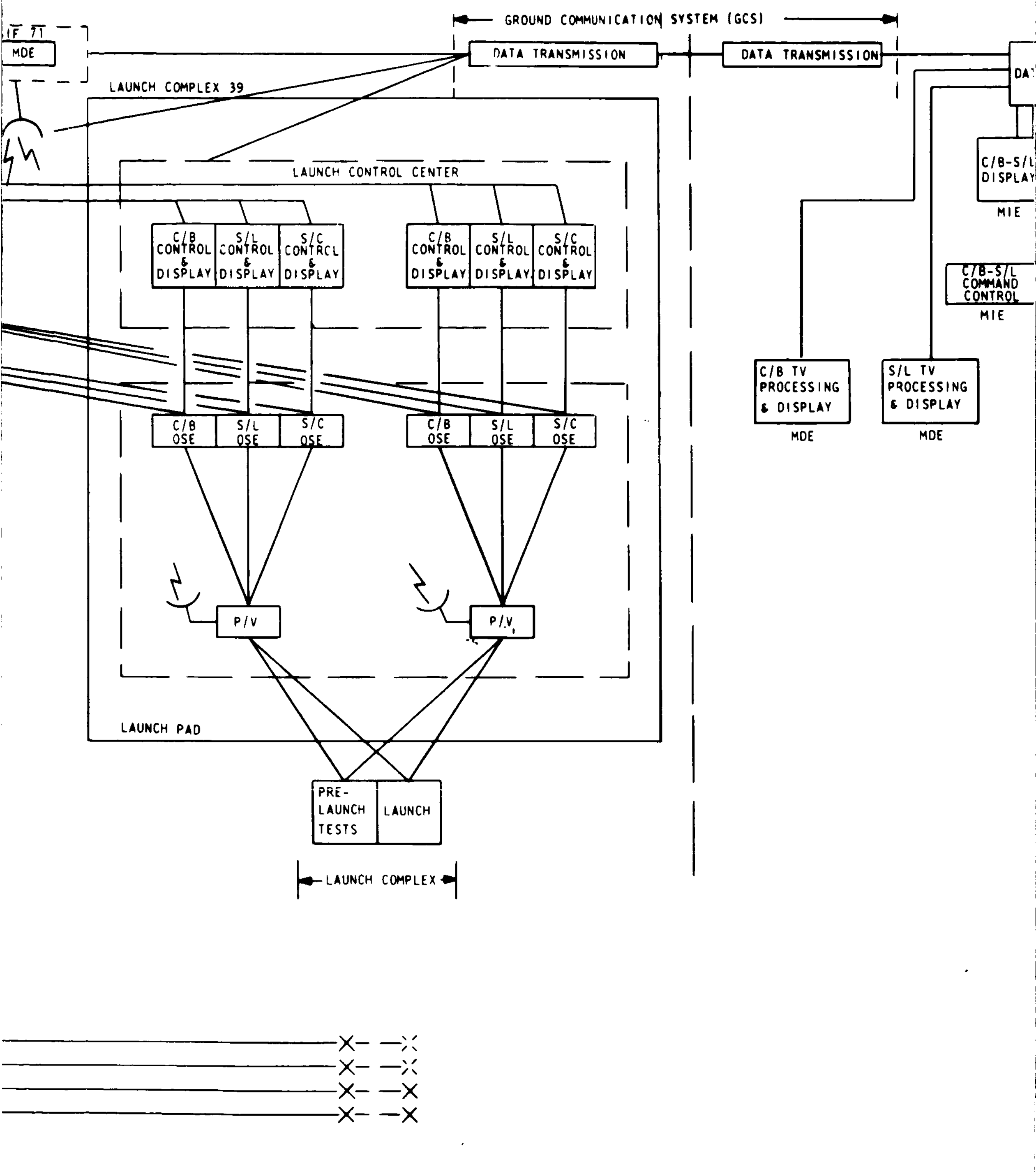
Fig. 1-7 Surface Laboratory

1-22-4



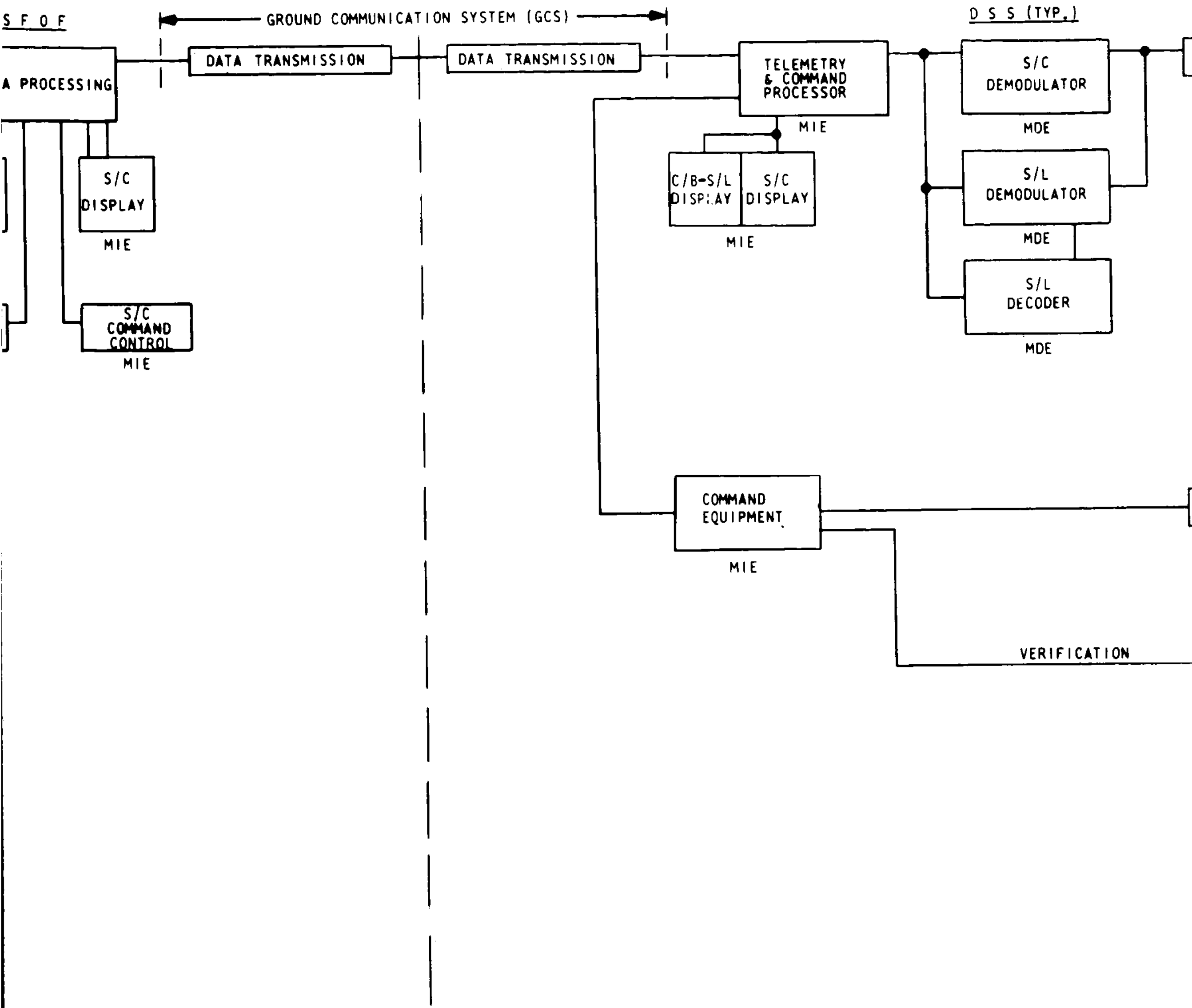
/Flight Capsule Test Flow Diagram

1-22-5



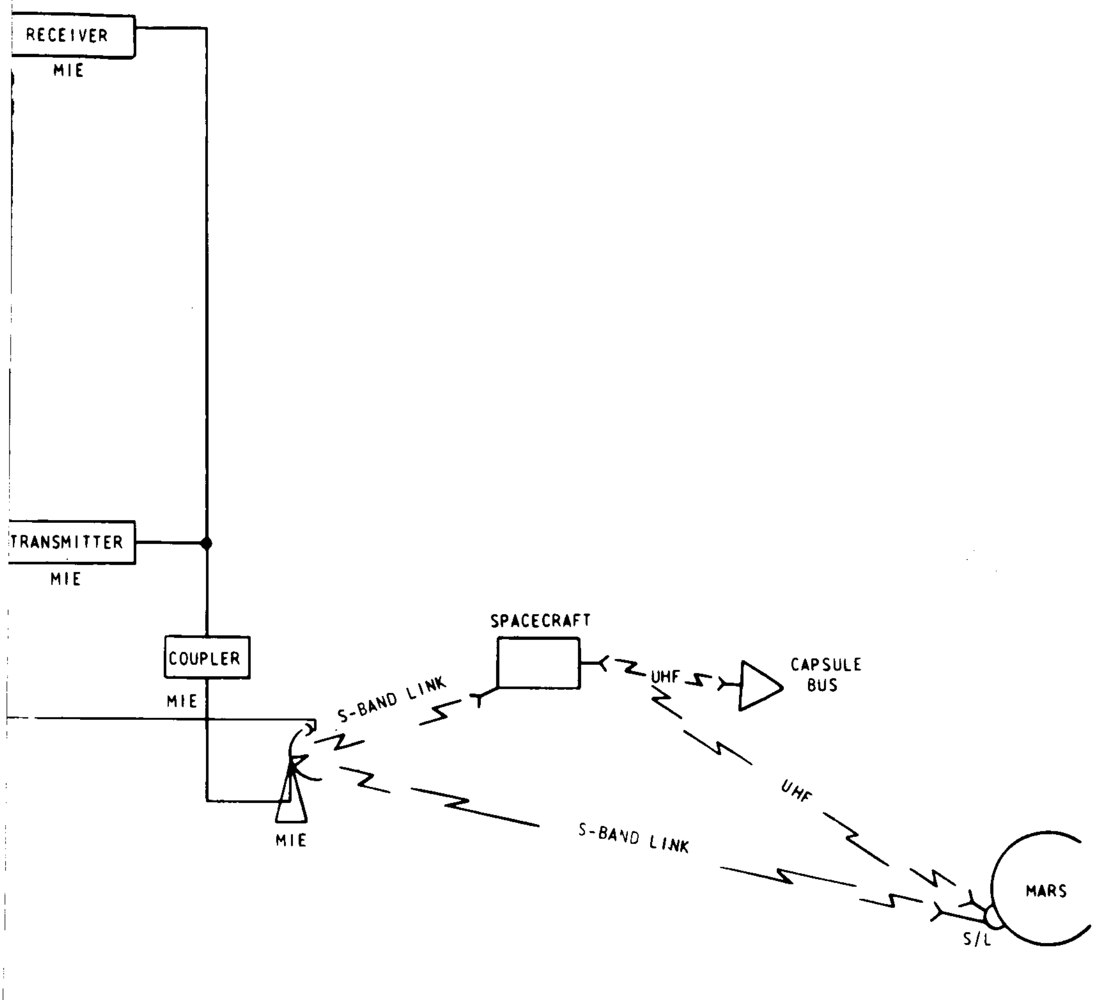
GROUND COMMUNICATION SYSTEM (GCS)
IF 71
MDE
DATA TRANSMISSION
DATA TRANSMISSION
LAUNCH COMPLEX 39
LAUNCH CONTROL CENTER
C/B CONTROL & DISPLAY
S/L CONTROL & DISPLAY
S/C CONTROL & DISPLAY
C/B CONTROL & DISPLAY
S/L CONTROL & DISPLAY
S/C CONTROL & DISPLAY
C/B OSE
S/L OSE
S/C OSE
C/B OSE
S/L OSE
S/C OSE
P/V
P/V
LAUNCH PAD
PRE-LAUNCH TESTS
LAUNCH
LAUNCH COMPLEX
C/B-S/L DISPLAY
MIE
C/B-S/L COMMAND CONTROL
MIE
C/B TV PROCESSING & DISPLAY
MDE
S/L TV PROCESSING & DISPLAY
MDE

1-22-6



SFOF
GROUND COMMUNICATION SYSTEM (GCS)
DSS (TYP.)
A PROCESSING
DATA TRANSMISSION
DATA TRANSMISSION
TELEMETRY & COMMAND PROCESSOR
MIE
S/C DEMODULATOR
MDE
S/C DISPLAY
MIE
C/B-S/L DISPLAY
S/C DISPLAY
MIE
S/L DEMODULATOR
MDE
S/L DECODER
MDE
S/C COMMAND CONTROL
MIE
COMMAND EQUIPMENT
MIE
VERIFICATION

1-22-7


RECEIVER
MIE
TRANSMITTER
MIE
COUPLER
MIE
MIE
S-BAND LINK
SPACECRAFT
UHF
CAPSULE
BUS
UHF
S-BAND LINK
MARS
S/L

a) Centralization of STC control center equipment (including the computer data system) to limit the number of intrafacility relocations of this equipment

b) Digital data transmission links between STC control center OSE and Capsule-vicinity OSE

c) Transportability of all STC equipment between test facilities such as Denver and KSC

d) Transportability for intrafacility relocations of Capsule-vicinity STC equipment

e) Test- or facility-imposed unique functional differences between test locations

3) Launch Complex Equipment (LCE) is required to support all test operations and monitoring activities at the launch complex.

4) Assembly, Handling and Shipping Equipment (AHSE) is required for:

a) Transporting and handling Flight Article systems within and between test facility locations

b) Transporting and handling OSE within and between test facility locations

c) Supporting special test requirements, such as module separation or deployment and cycling tests by special test fixtures.

1.3.1.3 Facility Considerations

Two facilities of special interest for the Surface Laboratory and Flight Capsule Systems besides the Surface Laboratory contractor's facility are Denver and KSC.

The physical locations of Denver facilities are as shown in Fig. 1-8. The facilities planned for assembly and test of the Flight Capsule include the Electronics Manufacturing Facility, the Manufacturing Assembly Building, the Spacecraft Assembly and Test Building and the Space Simulation Facility.

Surface Laboratory OSE functional support is required in the last two facilities where Flight Capsule System assembly and test operations are conducted. The Spacecraft Assembly and Test Building contains both assembly and test capabilities. This arrangement permits the permanent installation of most OSE in this building. Only Capsule-vicinity OSE relocation is required to support tests at the Space Simulation Facility because digital data links will provide the necessary data channel interfaces between these facilities.

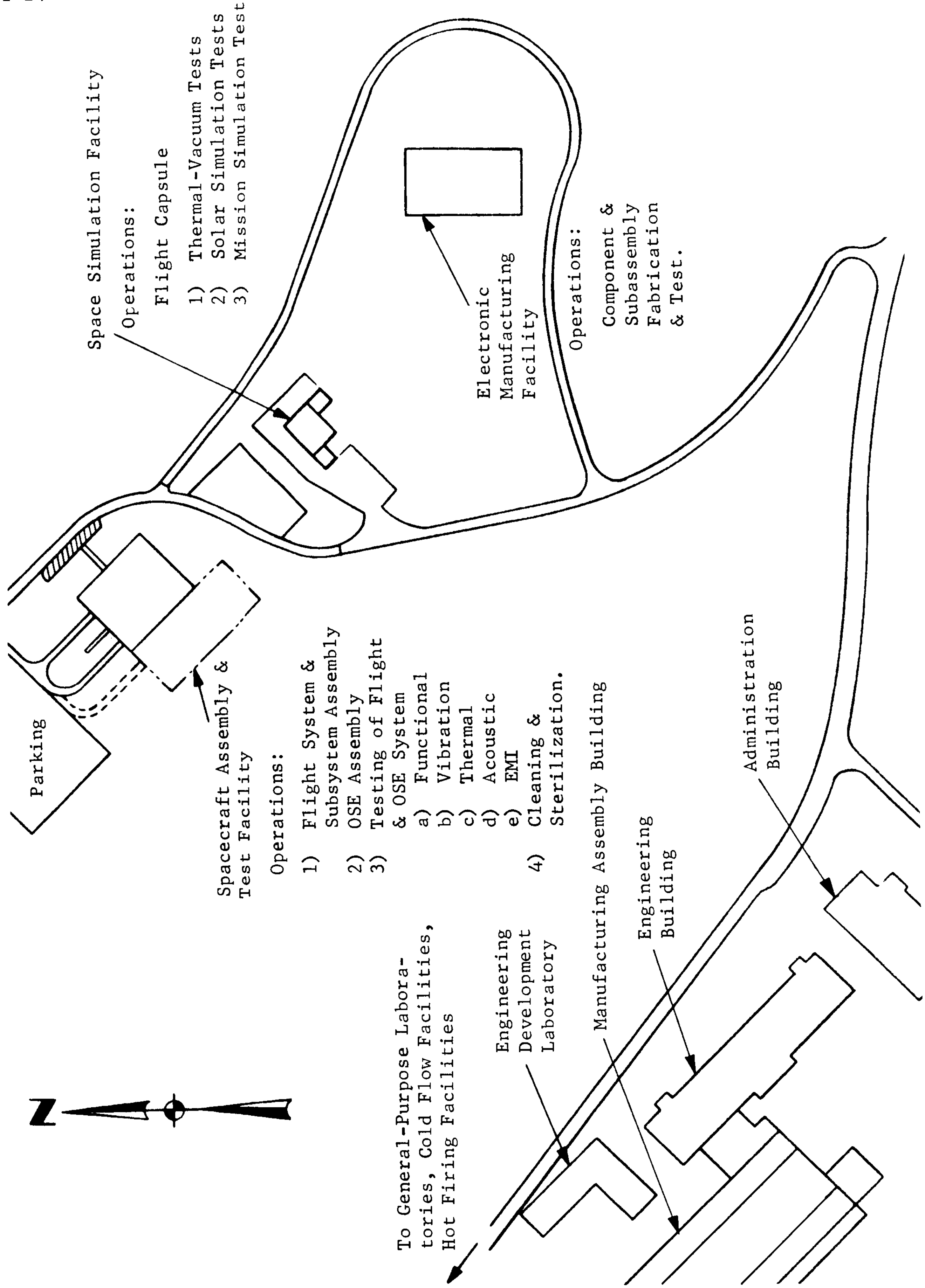


Fig. 1-8 Denver Facilities, Voyager Program

The locations of existing and planned KSC facilities are illustrated in Fig. 1-9. These facilities include: Launch Complex 39 launch pad and control center areas, Voyager assembly and test facility and DSIF-71.

The location for the Voyager assembly and test facility is assumed to be in the NASA Merritt Island Industrial Area, which appears to offer significant advantages in terms of the available support that can be derived from within the existing complex. It is further assumed that this building provides an integrated facility for both Spacecraft and Flight Capsule operations and includes space for the Systems Test Complexes.

The Launch Complex 39 launch pad and launch control center areas are used for Voyager prelaunch and launch operations. Because of the amount of Saturn equipment in each of these areas, space is assumed to be a constraining factor. Therefore, the use of A2A data links between these areas and the STC must be considered in order to reduce the amount of LCE.

The Deep Space Station (DSS-71) provides command, tracking, and data acquisition and processing functions during the initial phases of mission operations. The interface between this and other KSC Voyager facilities is by open-loop RF radiation. Prelaunch activities requiring open-loop transmission from both the Voyager assembly and test building and the launch pad are necessary. Line-of-sight provisions are, therefore, required between these areas.

Based on the above facility considerations, the following additional requirements are imposed on OSE:

1) Transportability of OSE is required to support relocations between contractor facilities, between Denver and KSC, and to a lesser extent to support operations within these facilities
2) Digital data links are required to connect remote areas
3) Line of sight between DSS-71 and the Planetary Vehicle is required for open-loop RF tests from the Voyager assembly and test building and the launch pad
4) The amount of LCE must be minimized because of limited space.

1.3.2 Trade Studies

Several of the more important design features were selected for additional detailed analysis and evaluation of alternatives. These design features pertained primarily to various configuration selections and were formalized in trade study reports identified in subsequent sections of this document.

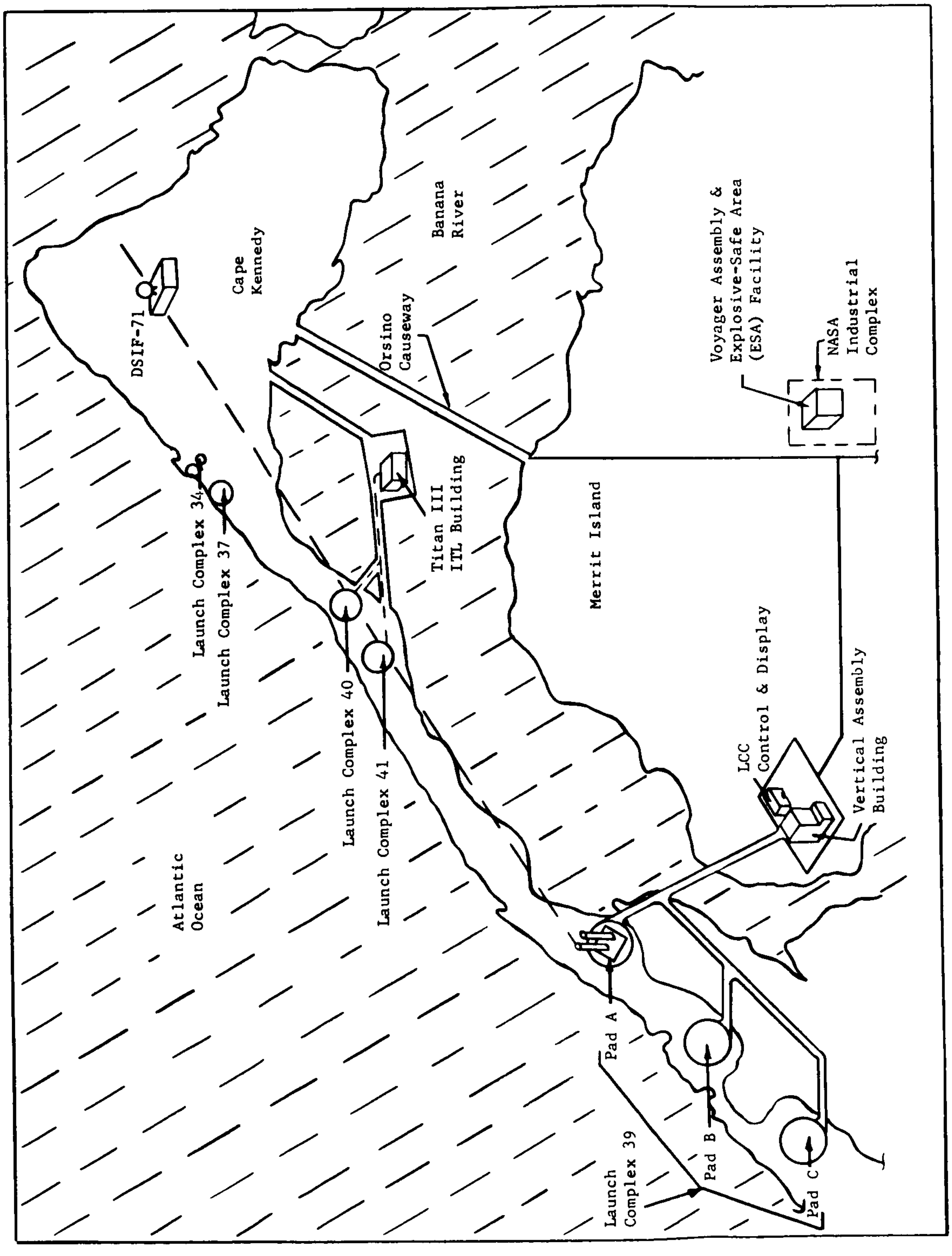


Fig. 1-9 KSC Facilities - Voyager Program

1.3.3 Problem Areas and Recommendations

1.3.3.1 Problem Areas

The following items appear to be significant to the further development of OSE configurations and preliminary designs.

1) Computer Implementation - There are two areas for concern in the identification of a computer data system for the STC:

   a) Compatibility of the Computer System with the DSIF - The STC has a significantly different task to perform than does the DSIF because it must service multiple PCM channels that include UHF channels not seen at a DSIF. In addition, the STC system must provide control, simulation, and supplementary discrete and analog data processing not required at DSIF. It may, therefore, be very difficult to maintain hardware commonality between the STC and the DSIF so that DSIF software programing can be adequately verified in the STC. This problem, however, may be minimized if selection of an up-graded DSIF computer system takes the STC requirements into account, or if a smaller DSIF computer is added to the STC.

   b) Computer Data System Selection - The computer data system selected for the C/B and S/L System Test Complexes depends on the use of identical computers for these systems. The requirement for identical hardware must also be accompanied by a corresponding requirement for identical software programs. The use of common test language and program subroutines is necessary for effective integration and economical design. These commonality requirements also extend to the computer input/output equipment particularly for the C/B and S/L systems. This is essential to assure pre- and post-integration compatibility between software systems.

2) DSIF Capabilities - DSIF capabilities for the Voyager mission must be clearly defined before MDE can be realistically specified. Areas of potential functional integration must be examined in detail after selection of Voyager System configurations and contractors. Coordination of contractor designs will establish the required DSIF interfaces, which can then be evaluated in terms of proposed capabilities. The areas that must be examined are signal demodulation, data decommutation and decoding, command generation and verification, display and recording.

3) Planetary Vehicle Integration - Present studies are based on several assumptions that require validation or correction to define the task of Planetary Vehicle integration. Some of the information needed for further OSE design activities includes:

a) Integration facility location

b) Command and telemetry interface with the Spacecraft

c) Integration of Spacecraft-Mounted Flight Capsule support equipment OSE into the Spacecraft STC.

4) KSC Facilities - Facilities planning information is required to define:

a) Location and arrangement of Voyager assembly and test facilities

b) Clarification of facility power interfaces

c) Space availability

d) Clarification of facility versus contractor-supplied communications

e) Availability of A2A remote data transmission links from the launch complex to the Voyager assembly and test facilities.

1.3.3.2 Recommendations

The items discussed below are suggested as subjects for further study and initial design emphasis.

1) Computer System Selection - A high priority should be assigned to the definition of computer systems for the Voyager contractors because of long lead time required to obtain computer system designs

2) Computer Software Programs - Decision must be reached early regarding implementation of computer system software because of software integration considerations. The use of a common test language program by all contractors can provide significant cost advantages relative to software development. This is substantiated by Martin Marietta experience with several systems presently using common computer test language programs. These systems are:

a) Computerized Aerospace Ground Equipment (CAGE) System presently under development by Martin Marietta under Air Force Contract

b) On-Board Checkout System (OCS) under development by Martin Marietta for NASA-Houston

c) Martin Manufacturing Computerized Assembly Test System (DIGIDAT). The CAGE and DIGIDAT systems use computer test language programs that have evolved through the development of OCS. The use of common computer test language programs for these systems has proved very beneficial in terms of development costs.

3) Telemetry Processing - Requirements for telemetry processing at the DSIF and in the various contractor System Test Complexes should be given early consideration to achieve maximum commonality among the systems. General-purpose PCM processing versus PCM preprocessing should be evaluated. Total loadings on DSIF computer systems should be determined. These loadings can be extremely heavy decommutation and decoding are accomplished for the proposed telemetry systems. The product of this study should provide the basic criteria for selection of computer system telemetry input devices.

2. SUBSYSTEM OSE

2.1 General Requirements and Concepts

Functional requirements for subsystem OSE are specified in the Voyager Capsule Systems Constraints and Requirements Document (SE003BB002-2A21). Additional requirements are specified below.

2.1.1 Subsystem OSE Configurations

Subsystem OSE configurations defined in this section are based on the following considerations:

1) Flight subsystem definitions and functional test requirements
2) Flight subsystem replacement levels
3) Flight subsystem spares levels.

Flight Subsystems - The Surface Laboratory includes the functional subsystems listed below. Subsystem OSE is provided to support development, qualification and acceptance testing of each of these subsystems.

Power	Communications (UHF and S-Band)
Pyrotechnics	Command and sequencing
Telemetry	Structures, mechanisms and thermal control
Landed science	Cabling.

Flight Subsystem Replacement Levels - Replacement levels are defined as the operational spares level for the S/L. They represent the packaged assembly level at which acceptance tests are conducted and at which installation assembly and malfunction isolation and replacement are implemented for the Surface Laboratory. The STC is required to isolate malfunctions to the replacement level during system testing. Subsystem OSE test sets are required to support development, qualification, and acceptance tests at the replacement level. If more than one replacement assembly is required for an individual flight subsystem, the test sets support these replacement levels both separately and together as a complete subsystem.

Flight Subsystem Spares Level - Flight subsystem spares levels are defined essentially as the depot or factory repair level of spares. They are those subassembly spares that are provided to support repair of the replacement level assemblies. These spares are acceptance tested in dummy replacement level assemblies. Subsystem test sets provided to support acceptance testing of replacement levels are also required to support acceptance tests at the spares level. These same test sets are capable of isolating malfunctions to the spares level during test of replacement assemblies.

2.1.2 Subsystem OSE Use of Computers

General Requirements - The concept of performing essentially all flight subsystem testing by use of general-purpose computers imposes the following general requirements on subsystem OSE.

1) Time-sharing of larger centrally located computer systems by subsystem test sets is required to minimize the number of computer systems required
2) Computer central processors identical to or compatible with the type selected for STC are used to provide maximum compatibility of software design for subsystem OSE and STC tests. This permits maximum flexibility of computer use because STC computer systems may also be used to support flight subsystem testing during peak testing periods
3) Computer support is provided for various subsystem test operations at the Surface Laboratory contractor's and subcontractors' facilities
4) "Minimum" computer systems are used by subcontractors in the interest of reducing costs. "Minimum" system in this case is defined as minimum computer memory, input/output, and peripheral equipment required to support subsystem test activities.

Functional Requirements - Flight subsystem development, qualification, and acceptance tests are accomplished by subsystem OSE test sets under control of a general-purpose digital computer system. The subsystem OSE computer system provides test sequence control, and data acquisition, processing and display functions for the subsystem OSE test sets. The subsystem test sets include the necessary interfacing equipment to permit accomplishment of the above functions by the computer system. To ensure maximum cost effectiveness and correlation of data for all subsystem and system level tests, standard equipment is used by all subsystem OSE test sets for flight subsystem and computer interfaces.

Standard computer test stations are permanently located at designated test areas and are used with the various test sets to perform flight subsystem testing. Testing is accomplished by the computer system and the subsystem test sets in real time and on a time-sharing basis between the various test stations. The overall concept is illustrated in Fig. 1-1.

2.1.3 Subsystem OSE Test Set Mobility

Subsystem OSE test sets are designed for mobility to facilitate relocation from one computer test station to another.

2.1.4 Unique Subsystem OSE Stimulus and Data Acquisition Equipment

Subsystem OSE designs include unique computer data acquisition and stimulus generation equipment required in the STC automated testing. Unique computer data acquisition and stimulus generation functions are defined as those functions that cannot be performed by standard equipment.

2.1.5 Subsystem OSE Packaging

Unique portions of subsystem OSE (e.g., RF signal generators and receivers) that are required in the STC are packaged in modules to readily permit incorporation of these modular units in the STC on a selective basis. Modular units may include chassis and even complete rack assemblies, so long as an efficient and cost-effective packaging approach is permitted for the STC.

2.1.6 Subsystem OSE Displays

Subsystem OSE test sets implement displays in a manner best suited to their individual needs, except that displays of common design are used for those functions that must also be displayed in the STC.

2.2 Subsystem OSE Computer Systems

2.2.1 Requirements and Constraints

The subsystem OSE computer system provides:

1) Complete functional testing of the various flight subsystems when used in conjunction with appropriate subsystem test sets
2) Central control of the various subsystem test sets individually or simultaneously through complete or selected portions of a subsystem test. Simultaneous testing of flight subsystems of the same or different designs is provided
3) Safeguards to prevent the occurrence of damage to subsystems due to improper sequencing of test steps
4) Ability to issue coded commands to the subsystem test sets for varying subsystem test parameters for performance testing
5) Man/machine interfaces with the computer to effect command/control and intervention of tests as required
6) Man/machine interfaces with the computer for call-up of subsystem test programs stored in computer memory
7) Acquisition, processing, distribution, and display of flight subsystem and subsystem OSE data for real-time and nonreal-time analysis
8) Man/machine interface with the computer for display of data and call-up of stored data
9) Hard copy printouts of data restricted to only necessary information required for real-time evaluation of the subsystem under test. Data display suppression, data averaging, and alarm monitoring are provided
10) Ability to play back previously recorded data for post-test analysis and evaluation
11) A central test recording and test log that includes:
    a) Identification of the flight subsystem under test and accumulated operating times
    b) Identification of tests performed, procedures in use, and step numbers
    c) Identification of data and time of tests
    d) A complete record of test data
    e) Ability to record subsystem test data

12) Automatic detection alarm and interruption for abnormal subsystem behavior during environmental tests (e.g., temperature, vacuum,)
13) Self-check capabilities
14) Decommutation of serially coded data streams
15) Central electrical power and distribution to the various elements of the computer system.

2.2.2 Preferred Preliminary Design

Subsystem OSE Computer System Definition - Analysis of requirements outlined in paragraph 2.2.1, together with analyses conducted in Phase B, result in the conclusion that two subsystem OSE computer system configurations are required to support S/L subsystem testing. The two configurations are illustrated in Fig. 2-1 and 2-2. Figure 2-1 illustrates the system required for the S/L contractor and Fig. 2-2 the system required for the communication (and TV) subcontractor.

The subsystem OSE computer configurations operate in a similar manner. The differences between the configurations are in the amount of bulk and core storage required, the number of test stations required, the amount and types of input/output and peripheral equipment provided, and the actual computer central processor selected. Flight subsystem complexities, quantities and number of different types that must be tested at the various areas are factored into the selected configurations. For example, considerations for subcontractors indicate that generally only one or two flight subsystem types need to be supported, consequently fewer test stations, less bulk and core storage, and less peripheral and input/output equipment are required.

The subsystem OSE computer system used to support testing of the Surface Laboratory subsystems (Fig. 2-1) uses a computer central processor identical to the type selected for STC. This selection is made to provide software compatibility with STC and to permit the use of STC computer systems to supplement the subsystem OSE computer system during peak subsystem test periods.

The subsystem OSE computer system required for the S/L communications (and TV) subcontractor (Fig. 2-2) uses a computer central processor compatible with the type selected for STC. This selection is made to provide software compatibility between subsystem OSE and STC computer systems. An STC-compatible (but less expensive) processor is selected for this system rather than one identical to STC because subsystem test loads are significantly less than for the S/L contractor.

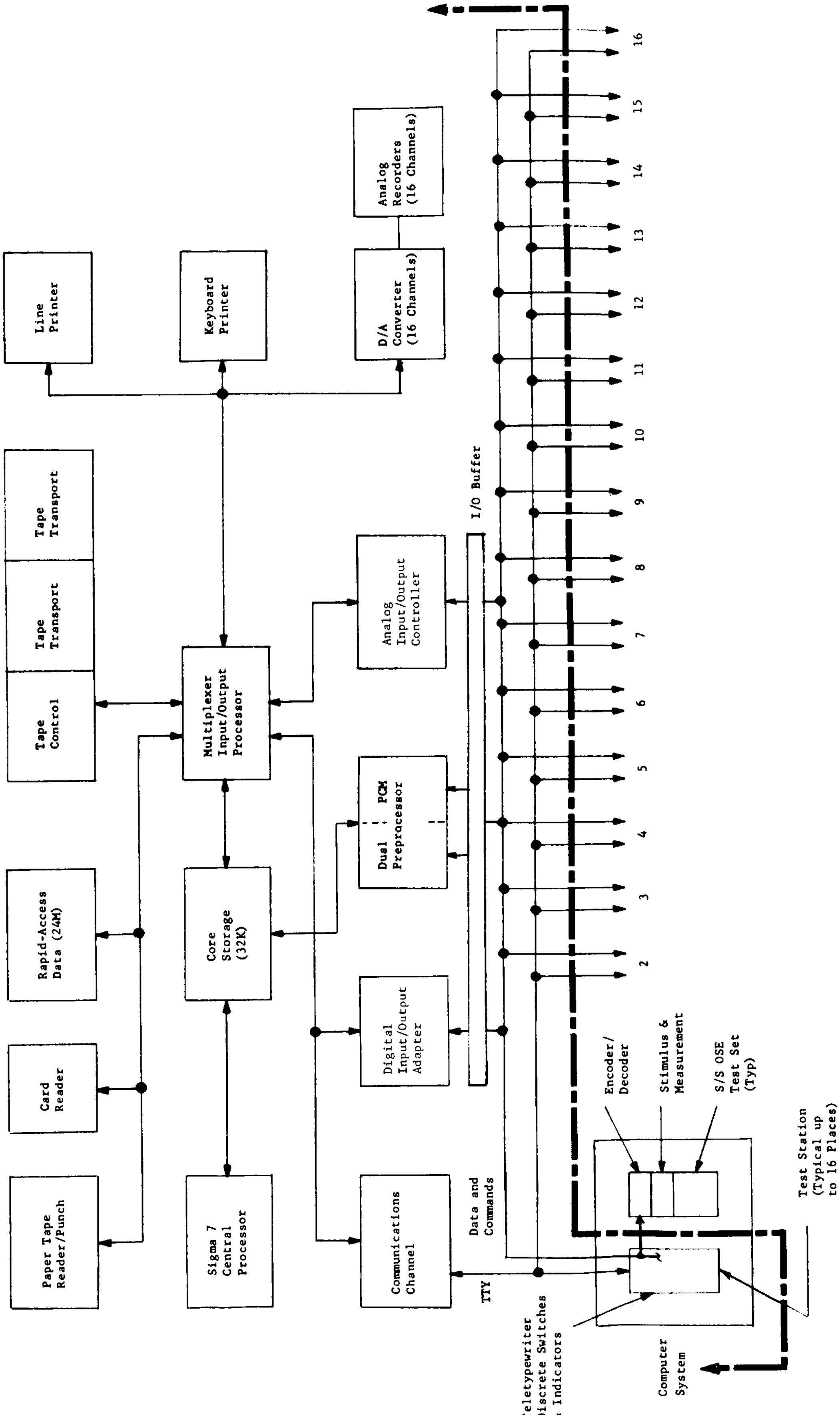


Fig. 2-1 Subsystem OSE Computer System Configuration

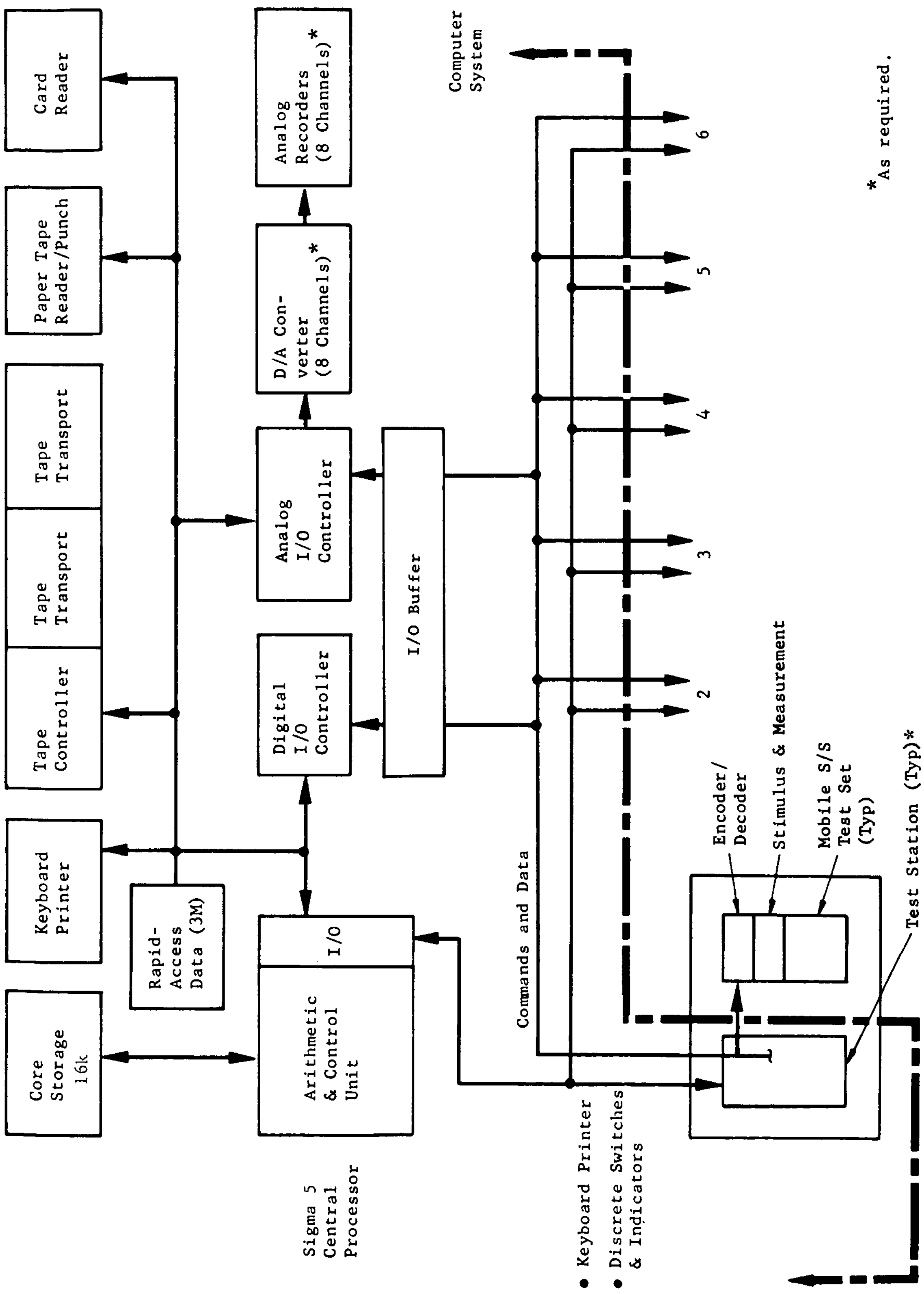


Fig. 2-2 Typical Subcontractor Subsystem OSE Computer System Configuration

Functional Description - The functional description provided in the following paragraphs is typical of the computer systems discussed above.

The subsystem OSE computer system uses a general-purpose digital computer and subsystem test sets to provide the required ability to test various flight subsystems. The computer system provides test sequence control, data acquisition, storage, processing and display functions for the various test sets. The test sets include all the standard and unique computer interfacing equipment for generation of stimuli and commands, and conversion of data to digital form for processing by the computer. The test set standard computer interfacing equipment includes the necessary address decoding and encoding equipment.

Testing is accomplished under computer program control from any of the remote test stations upon operator request. Testing is performed in real time and on a time-sharing basis between the various stations. Capability is also provided for off-line post-test evaluation of data.

A time-sharing system monitor program is provided with test programs written in a test-oriented language. A translator program converts the test program language statements from punched cards or tape into computer code and stores the coded programs in bulk storage. The test programs are transferred from bulk storage to core storage from any of the test stations upon operator request. The test programs are executed upon operator command, resulting in the issuance of commands and evaluation and display of data as appropriate. Priority interrupts are used to notify the computer system when test station data requires processing by the computer. The computer system responds to the priority interrupt in accordance with the system monitor program provisions and commands the subsystem test sets at that particular station to dump data stored in their registers into core storage. The computer then processes the data and provides results to the test station.

Provisions are included in each computer system remote test station for command/control and intervention of tests. Discrete switches are provided for manually issuing commands to the computer systems and discrete light indicators are also included for displays. A teletypewriter is provided for each remote station for call-up of test programs, and display of anomaly data or requested data, alarm messages and instructions issued by the computer.

<u>Physical Characteristics</u> - A typical subsystem OSE computer system is illustrated in Fig. 2-3. It can be divided into three functional groups. Because these equipment groups are similar to STC, descriptions can be found in paragraph 3.2.2. The three groups are input/output, central processing, and control and display groups.

The input/output group buffers and conditions the signals between the computer system and the test stations and includes the following items:

Communications channel	D/A converters
Digital (Input/Output) adapter	PCM preprocessor
Analog I/O controller.	

The central processing group operates on the incoming data after proper formatting by the I/O equipment. The central processing equipment analyzes the data, stores the results, and drives peripheral display units. The central processing equipment includes the following:

Central processor	Keyboard printer
Core storage	Tape control and transports
Bulk storage (rapid access data)	Paper tape reader/punch
Multiplexer I/O processor	Card reader

The control and display group provides the man-machine interface with the computer system, including the line printer and analog recorders similar to those used in STC. Also included in this group is the test station control and display equipment that consists of a teletypewriter and a standard single-bay console. The console contains discrete switches for command/control and intervention and discrete light indicators for test status as required.

<u>Description of Interfaces</u> - The following paragraphs identify physical and functional interfaces for the subsystem OSE computer system.

Facility Interfaces - The facility interfaces are

1) Space - Space provisions are required for the central computer equipment and the remote test stations
2) Environmental - A controlled environment is required for the central computer system and remote test stations
3) Power - 120/208 vac, 60 Hz, 3 Φ and single phase for the central computer system; 120 vac, 60 Hz, single phase at each remote test station.

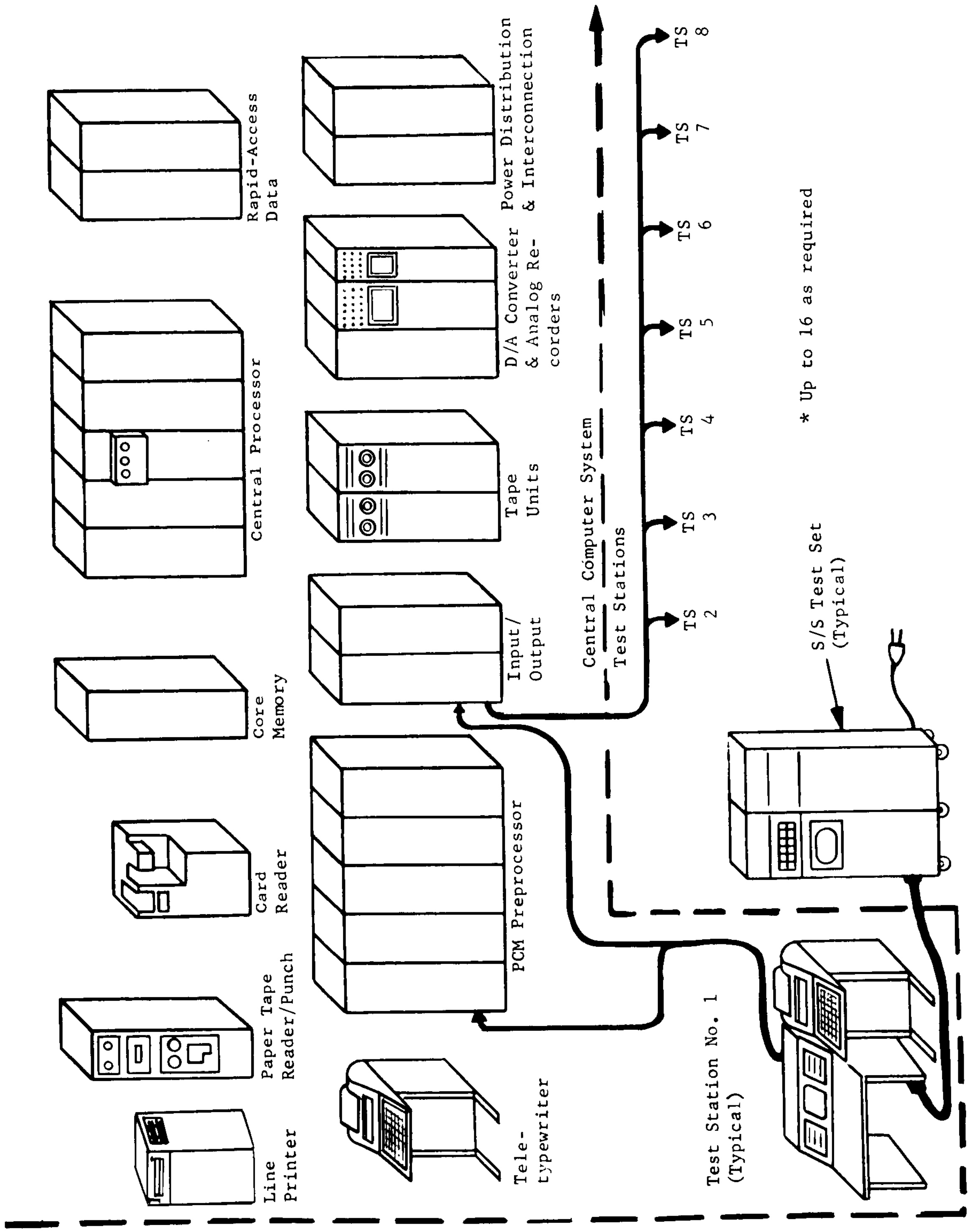


Fig. 2-3 Subsystem OSE Use of General-Purpose Computer

Subsystem OSE Test Set Interfaces - Standard provisions are included at each computer system remote test station for connection of subsystem test sets. The standard interface provisions are for routing commands from the computer system to the subsystem test set and data from the test set to the computer system.

2.2.3 Subsystem Analysis and Trade Studies

The following customer-imposed requirements established the basis for evaluating the feasibility of general-purpose computer use by subsystem OSE.

1) Subsystem OSE must be capable of:
   a) "Performing all test routines expeditiously, correctly, and repeatedly"
   b) "Interfacing with a general-purpose computer system for test sequence control or direction and data acquisition and display"
2) STC must be capable of "centrally controlling or directing the Capsule or any of its subsystems individually or in combination through a complete or selected portion of a system test by use of a general-purpose computer system."

Requirement 1a implies that some form of automatic test control and evaluation of flight subsystems may be required for the more complicated subsystem OSE test sets. Because many of the subsystems are fairly complex, consideration of alternative methods of automated testing was appropriate. The use of general-purpose computers warranted consideration as one of the alternative approaches because of requirements 1b and 2 above. Consequently, the following alternative methods of implementing test control and evaluation for the more complicated test sets were considered:

1) Use of small general-purpose computers as an integral part of the test sets
2) Use of tape programers and associated logic and control circuits.

The use of small computers was recommended for telemetry, science, and communications (and TV) subsystem OSE. These recommendations were based on the large quantity and variety of digital and other data that required processing.

2.2.3.1 Subsystem OSE Use of Central Computer Systems

Based on the above recommendations, consideration was subsequently given to the feasibility of test sets time-sharing central general-purpose computer systems. This approach was attractive because of potential hardware and software cost savings and because it offered possibilities for testing essentially all flight subsystems by the use of general-purpose computers. Therefore, the following alternatives were evaluated.

1) Use of STC computer systems on a shared basis (noninterference with STC)
2) Use of a number of smaller, individual STC-compatible computer systems (A small computer system would be provided for each major subsystem and would be time-shared by a number of test sets of the same or different designs.)
3) Use of small individual computers in subsystem test sets.

Real-time sharing of STC computer systems with subsystem OSE was considered as a fourth alternative. This alternative provided the ability for simultaneous testing of Flight Capsule Systems and flight subsystems. However, it was dropped from serious consideration because of schedule problems, high cost, and risks involved in developing the more complicated software.

To maintain a consistent policy relative to the use of computers for flight subsystem testing, consideration was also given to subcontractor-furnished equipment. The recommendation resulting from this consideration provides a "minimum" STC-compatible computer system for each subcontractor. Based on this recommendation, each of the primary alternatives identified above assumed that smaller STC-compatible computers are used by subcontractors to permit continuity of this concept.

Although alternative 1 (sharing of STC computers) is the most cost-effective approach, it was not selected because of the apparent inability to support projected test schedules for both system and flight subsystem tests. The requirement for concurrent test capability for system and subsystems, in addition to the requirement for maintaining subsystem test capability throughout the life of the program, precluded its selection.

Alternative 2 was eventually selected over alternative 3 because:

1) It is less costly
2) It permits the use of common software between subsystem OSE and STC
3) It provides the ability to perform essentially all subsystem tests by the use of a computer.

Although alternative 2 was selected over alternatives 1 and 3, the recommended approach is the one described in paragraph 2.2.2 above. This approach is, in essence, a modification of alternative 2 above. The major difference is in the number and size of computer systems. Alternative 2 would have provided two smaller computer systems for the S/L contractor whereas the proposed approach provides one large computer system. This selection was made on the basis that at least one of the STC computer systems for the S/L contractor would be available to support flight subsystem production testing during peak testing periods.

2.2.3.2 Problem Areas and Recommendations

Further study is required in the following areas to ensure optimum implementation of flight subsystem testing by use of general-purpose computer systems.

1) Location of standard decoding and encoding equipment in computer test stations versus location in individual subsystem OSE test sets as proposed
2) Evaluation of alternative real-time sharing techniques for the various subsystem OSE test sets. This evaluation should take into account both computer system hardware and software designs to optimize common use of software designs for subsystem OSE and STC.

2.3 Structures and Mechanisms

2.3.1 Requirements and Constraints

General Requirements - The structures and mechanisms control-monitor OSE for the Surface Laboratory System provides all the functions necessary to test and check out the structures and mechanisms to ascertain the operational integrity of the subsystem.

Functional Requirements - The structures and mechanisms control-monitor OSE is designed to provide the following functions: (1) controls and monitors the mechanisms that deploy and aim the TV cameras; (2) controls and monitors the mechanisms that deploy and aim the TM antenna; (3) controls and monitors the mechanisms that deploy the atmosphere sampling probes; (4) controls and monitors the mechanisms that deploy the soil sampling probe; (5) controls and monitors the mechanisms that deploy the metabolism detectors and alpha scattering experiment.

2.3.2 Preferred Preliminary Design

The preferred preliminary design to satisfy the above requirements for qualification and acceptance is an item of OSE identified as structures, mechanisms, and thermal-control monitor set.

Subsystem Definition - The structures, mechanisms and thermal-control monitor set is an electrical/electronics item with the ability to control and monitor ordnance operated devices, servo mechanisms, and linear motion and position transducers. The set also has the ability to simulate electrical interface functions provided by other S/L subsystems.

The set can be operated manually or automatically when supported by programed input signals from the subsystem OSE computer system. The set contains the thermal control OSE described in paragraph 2.4. A functional block diagram of the set is shown in Fig. 2-4. The set is used at the S/L contractor's facility to perform the functional requirements listed in paragraph 2.3.1 and paragraph 2.4.1. As secondary performance characteristics, the set provides:

1) Simulated input signals to the S/L structures and mechanisms representing other S/L subsystem outputs
2) Overload protection of all circuits
3) Emergency shutdown in a fail-safe mode
4) Self-checks such as lamp test, continuity test, and calibration checks
5) Forced-air ventilation for component cooling
6) Test points for malfunction isolation
7) Both manual and computer control of functions in any sequence
8) An operating time indicator.

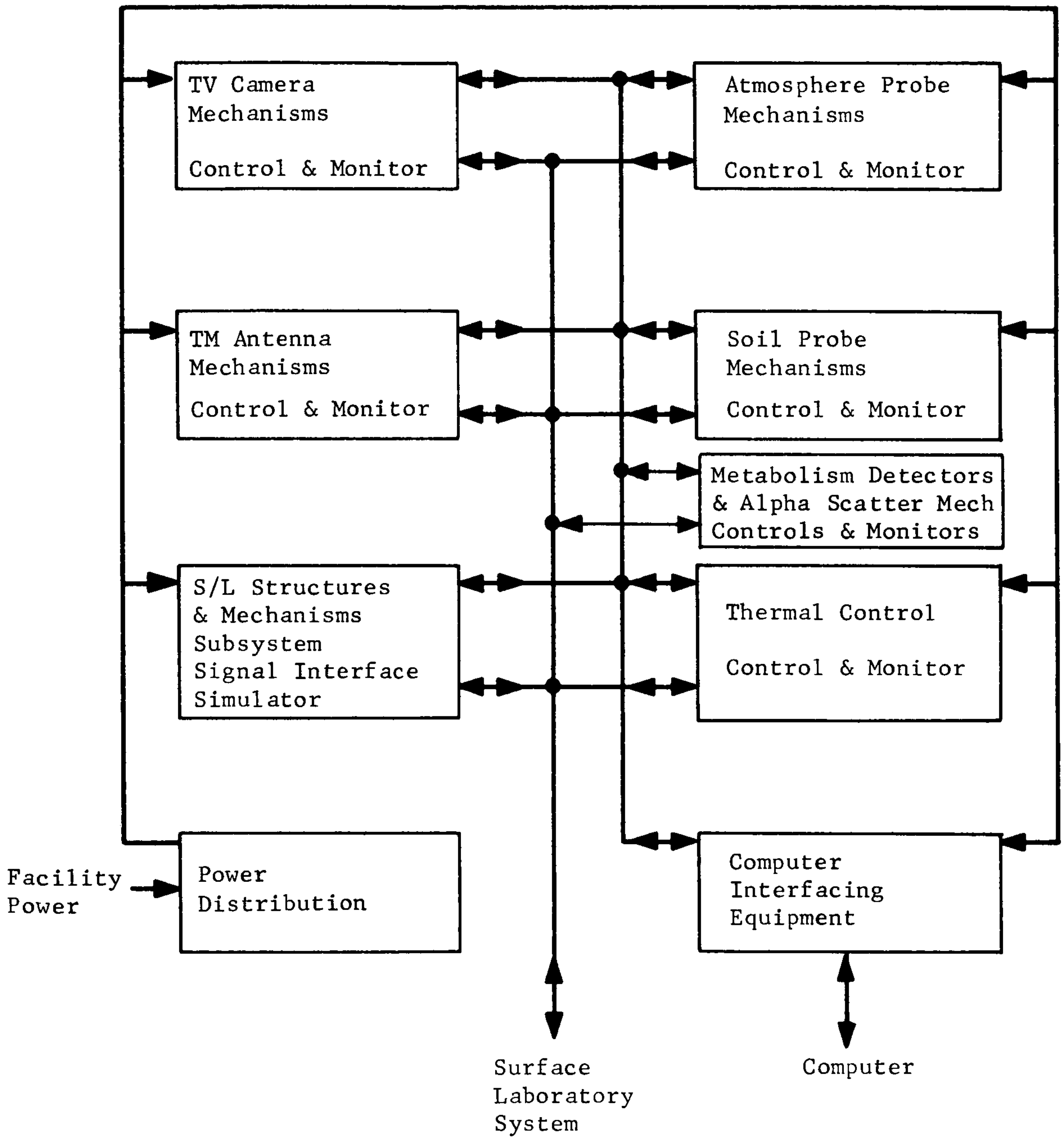


Fig. 2-4 Structures, Mechanisms and Thermal Control Monitor Set

Physical Characteristics - The set is a portable unit consisting of one electronics rack with a cable set mounted on a supporting structure with skids and/or casters. The electronics rack is 82 in. high, 22 in. wide, 27 in. deep and weighs approximately 400 lb. It is designed to operate in a sheltered conditioned environment by one operator in a standing position. Operational controls, light indicators, analog readouts, and test-point connectors are on the chassis front panels. Calibration controls are on chassis subpanels with easy access for adjustments. Power requirements for the set are 20 amp at 28 vdc and 5 amp at 120 vac, 60 Hz, single phase.

Description of Interfaces - The set has electrical interfaces with the S/L structures and mechanisms subsystem for the functions listed in paragraph 2.3.1 and paragraph 2.4.1; with the subsystem OSE computer system and with the facility power distribution system. The set also has a physical interface with the facility. Fig. 2-5 shows a schematic arrangement of interfaces for the set.

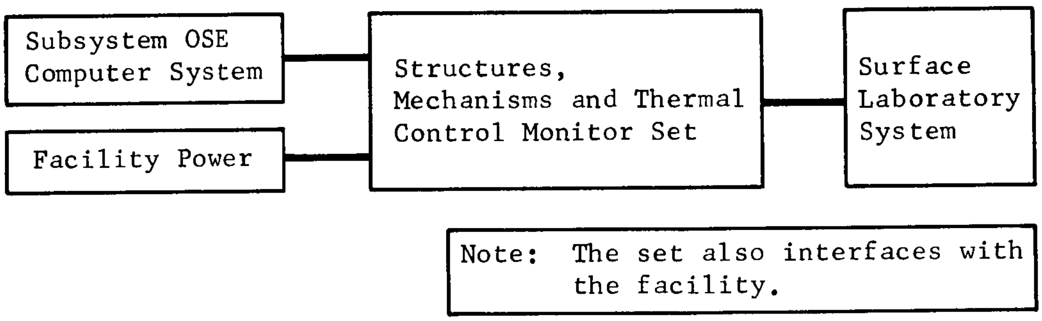


Fig. 2-5 Structures, Mechanisms and Thermal Control Monitor Set Interface Schematic

2.4 Thermal Control

2.4.1 Requirements and Constraints

General Requirements - The thermal control test support equipment and the environmental space chamber facilities provide all the functions necessary to test and check out the thermal control subsystem to ascertain its operational integrity.

Functional Requirements - The thermal control test support equipment is designed to:

1) Test and verify the operation of electrical heaters, thermostats, and temperature sensors

2) Validate thermal performance of thermal insulation materials

3) Validate thermal emissivity and absorptivity of optical finishes.

2.4.2 Preferred Preliminary Design

The preferred preliminary design of the equipment to satisfy requirements 2 and 3 above is laboratory test equipment and facility instrumentation. This equipment is used to validate the thermal properties of the S/L thermal control subsystem. This equipment is not subsystem OSE. The preferred preliminary design of the equipment to satisfy requirement 1 is one chassis in the structures, mechanisms and thermal-control monitor set. The power distribution portion of this set is shared for the thermal-control functions.

Physical Characteristics - See paragraph 2.3.2.

Description of Interfaces - See paragraph 2.3.2.

2.5 Command and Sequencing (C&S)

The command and sequencing subsystem test set is used in conjunction with the subsystem OSE computer system, to test and ascertain the operational condition of the Surface Laboratory subsystem during all phases of subsystem testing. A complete description of the subsystem and its functions is in Volume III, Section I, paragraph 3.3 of this report.

2.5.1 Requirements and Constraints

The preliminary design of the C&S test set satisfies all the general requirements enumerated in paragraph 2.1.1 above, as well as the following functional requirements:

1) Loading of a special checkout program into the subsystem memories and verification of memory contents
2) Monitoring 150 momentary (150 ms) timed and 12 direct command discretes
3) Generating 15 continuous input events
4) Generating 27- and 31-bit update digital binary words, the proper sync, and control voltages
5) Accepting 24-bit update digital binary words, the proper sync, and control voltages
6) Accepting 7-bit telemetry digital binary status words, and generating of the sync and control signals for reading the words
7) Verification of internal redundancies and decoder ability to detect bit errors (parity)
8) Determine condition of most significant bits in the 1-sec clock counters.

2.5.2 Preferred Preliminary Design

The test set is basically an input/output mechanization for use with the OSE computer system and consists mainly of conditioning, loading, and selection circuits (Fig. 2-6). Program control and data evaluation are accomplished by execution of a test program stored in the subsystem computer system, available on a time-sharing basis with other subsystems by call-up from a test station located near the C&S subsystem test set.

Subsystem Definitions - The subsystem is made up of two spares levels, the command decoder and the sequencer timer, and one replacement level, the subsystem. The test set operates and tests the subsystem and isolates anomalies to the spares level.

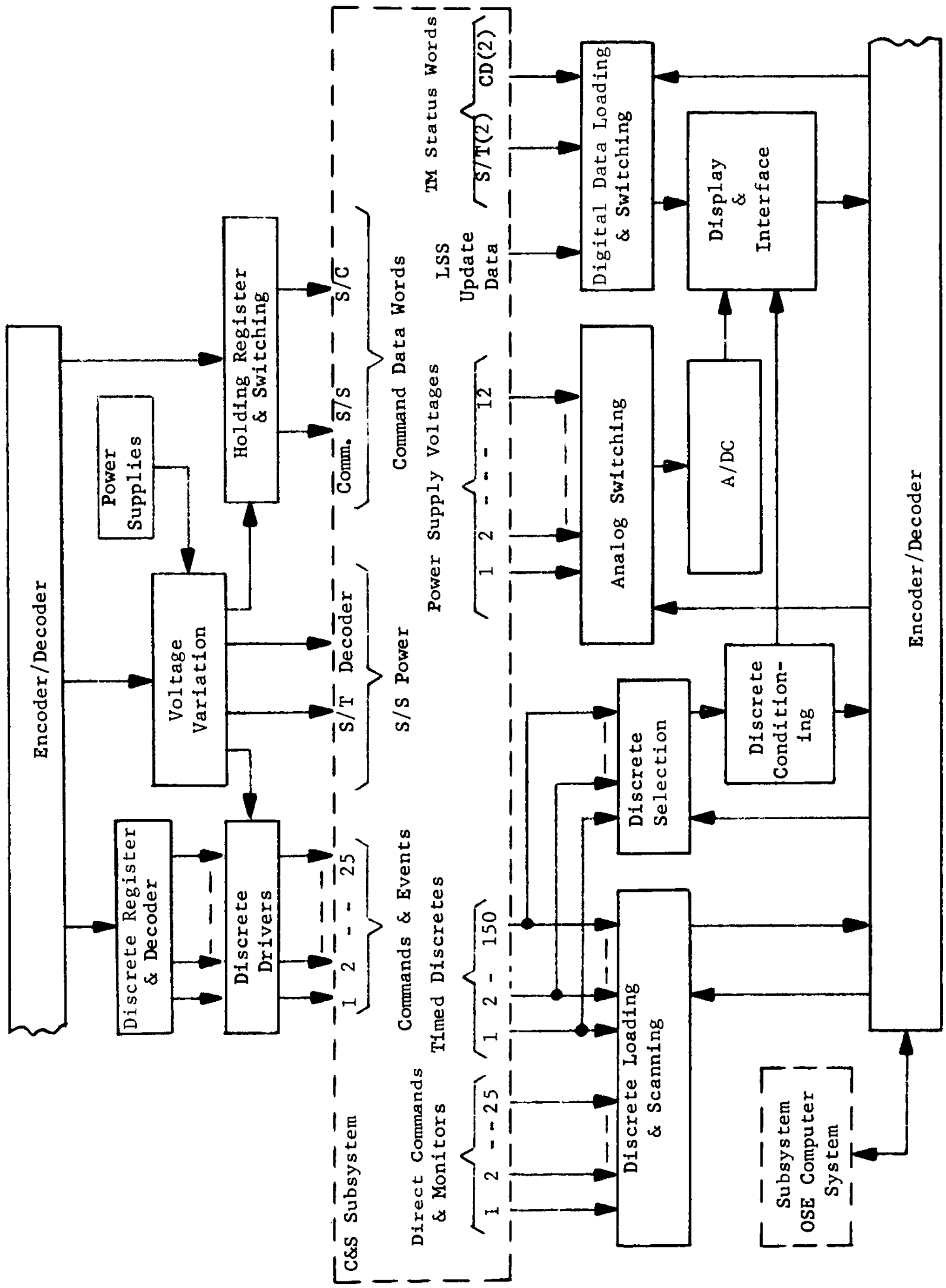


Fig. 2-6 C&S Test Set Block Diagram

The C&S test set simulates all interfaces normally seen by the subsystems when operating at the system level. Loading of subsystem outputs is at maximum load conditions, and simulated voltages are programable for marginal and extended stress testing.

Discrete commands (input events and special checkout requirements) to the subsystem are generated as shown in Fig. 2-6. A binary coded, discrete data word from the computer is clocked into the discrete register. A decoder determines which of the available discretes is to be operated on and whether it is to be turned on, off, or pulsed. The discrete drivers prevent loading of the decoder, simulate source impedances, and supply the controlling voltage to the subsystem interface.

Output-circuit supply voltage is provided by the programable voltage variation circuits so that various signal voltage levels can be furnished to the subsystem; they also provide operating power to the subsystem so that performance can be evaluated with selected values of prime power. A data word maintains individual program control over the outputs of the voltage variation circuits. Command data words are loaded into the holding register and clocked into the subsystem via the switching circuits together with a beginning of word event discrete. The digital data words (update data words and telemetry status words) are appropriately loaded and, depending on which test is to be performed, one of the words is selected and loaded into the display and interface circuits.

All discrete outputs of the subsystem are loaded at the OSE input and tested periodically for an unwanted signal on any one of the interface lines. Timed discrete outputs are routed in groups to the discrete conditioning circuits. The twelve power-supply voltages are switched on command into a 10-bit plus sign analog-to-digital converter, the output of which is routed to the display and interface circuits.

The discrete conditioning circuits convert time-dependent discrete occurrences into serial bit streams for evaluation by the OSE computer. An event discrete is issued to the subsystem to initiate the programed time delays, and it enables clock pulses to be accumulated in binary counters; occurrence of a discrete stops its respective counter. The 19-bit counters have a capacity of 2^{19} -1 or 524,287 bits. With a clock frequency of 100 kHz, the counter capacity is 5.24287 sec. If a time delay exceeds the counter capacity, an overflow no-go is displayed with no further data evaluation of that discrete. With the counter stopped and no overflow condition, the measured time data word is shifted to the display and interface circuits for transmission to the OSE computer where it is compared to early and late time tolerances. A no-go inhibits any movement of data so that the currently displayed anomaly can be evaluated.

Because the checkout software uses only a small portion of the subsystem's total time capability (5 sec maximum, compared to 2^{16} -1 or 65,535 sec), the discrete conditioning circuits determine the conditioning of the most significant bit in the subsystem 1-sec clock counter(s). The normal input to the counter is disabled and it is set up to count a pulse train from the OSE. The pulse train sets the 2^0 through the 2^{14} flip-flops to the one condition but not the 2^{15} flip-flop. This is confirmed by the OSE computer. The last pulse of the train, delayed to allow the check just mentioned, sets the 2^0 through 2^{14} flip-flops to zero and 2^{15} to one. This condition is also confirmed by the computer.

The display and interface circuits are used to hold measured value data words until called for by the OSE computer, to store upper and lower test limits in shift registers, and to display contents of the registers in the event of a no-go or if manually requested by the operator.

Integration of these elements into a functional system is accomplished by a test program stored in the subsystem OSE computer. The checkout software contains the test sequencing, voltage levels, monitor and application points, criteria for successful completion, and, in general, describes the means of ascertaining the operational condition of the subsystem.

Checkout Sequence of Operations - It is not desirable to run the checkout sequence in mission real time because a block of discretes that depend on a single event may be issued over a period of several hours. Therefore, the checkout programs loaded in the subsystem memories are written so that the output discretes from the subsystem are grouped in blocks; each block depends on one of the input events, and the discretes in each block sequenced in 1-sec intervals.

Functional testing of the subsystem begins by moving the C&S subsystem test set in place near an OSE computer system test station and connecting to it. The harnesses that simulate the Surface Laboratory and direct-access cabling are connected between the subsystem and the test set, facility power is connected and prime power applied. At the test station teletypewriter, the operator initiates a request for a subsystem test on the keyboard. The computer retrieves the requested test program from its memory and the test sequence is initiated. The computer controls the testing, but the operator has the option of stopping and starting test sequences, repeating tests, or calling up data. Displays and controls available are the teletypewriter, discrete switches at the test station, discrete lights to indicate status and progress of the testing, and the display and interface circuits register displays (upper limit, measured value, and lower limit).

The test sequence begins with a self-test of the C&S test set by the OSE computer system. This consists of filling registers with programed values, measurement of power supply voltages by the A/DC and similar tests for all other functional units.

After successful completion of self-test, power is applied to the subsystem; power supply voltages, clock frequencies, and reset conditions are verified; and the clocks are synchronized with the OSE clock. Using the Spacecraft and the communications subsystem command data words as input, the subsystem is commanded to issue each of the direct command discretes, and update information to the landed science subsystem interface; status of the subsystem (contents of the four telemetry registers) is monitored for each condition. Improper command data words (parity errors) are generated and the subsystem capability of error detection is verified. The checkout programs are loaded into the subsystem memories via the command data word interfaces and verified by monitoring the telemetry status registers. Mission events are simulated and the timed discretes dependent on each event are checked for proper occurrence times. The 10-Hz clocks are disabled and the condition of the most significant bits in the 1-sec clock counters are tested. The magnetic registers are exercised by loading a number of pulses into the 1-sec clock counters, removing subsystem power, reapplying power, and loading the remainder of the pulses necessary to set the 2^{15} bits to one; criteria for successful completion are the same as for the most significant bit test. Selected test sequences are repeated, varying power and signal voltage levels within the design range and beyond to test the subsystem's ability to operate with marginal inputs.

Physical Characteristics - The arrangement of the subassemblies within the test set rack is illustrated in Fig. 2-7. The test set consists of four equipment chassis and a blower housed in a mobile, standard electronics rack approximately 82 in. high and requiring 23x27 in. of floor space.

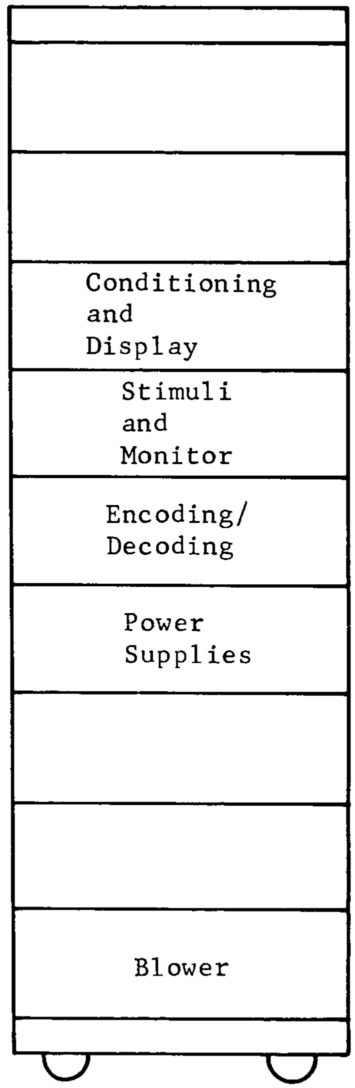


Fig. 2-7 Command & Sequencing Test Set

2.5.2.3 Description of Interfaces

The command and sequencing test set has three interfaces: the subsystem under test, subsystem OSE computer system, and the facility. The OSE input/output functional interfaces are:

Input

Subsystem - 12 power-supply voltages (2 each: ±5, ±12, +24, -2 vdc); 175 discretes (24 to 32 vdc); 9 digital (4 serial data, 2 sync, and 3 clock)

Subsystem OSE computer system - 2 discretes (24 to 32 vdc); 2 digital (1 serial data, 1 clock)

Facility - Nominal 120 vac, 60 Hz, single phase, 300 w

Output

Subsystem - 2 analog dc voltage (20 to 37 vdc); 35 discretes (20 to 37 vdc); 6 digital (4 clock, 2 serial data)

Subsystem OSE computer system - 2 discretes (24 to 32 vdc); 1, 32-bit parallel data word.

2.6 Landed Science

This section describes the particular requirements and the design of the OSE associated with the landed science portion of the Voyager Surface Laboratory. It also includes discussions of the alternative concepts considered and evaluated.

The Landed Science Subsystem (LSS) is composed of:

1) Science data subsystem (SDS) with data storage
2) Sample Acquisition and processing system (SAP)
3) Experiment instrumentation
    a) Insolation (radiometer)
    b) Soil composition (alpha-scattering spectrometer)
    c) Atmospheric (temperature, pressure, humidity and wind)
    d) Gas composition (gas chromatograph, mass spectrometer)
    e) Life detection (biological analyzer and metabolism detector)
    f) Visual imaging (television).

The block diagram of the LSS reference configuration is shown in Fig. 2-8.

This equipment contains a high-bandwidth digital system, precise electronic and biochemical instrumentation, and an intricate electromechanical device. Its units are mounted throughout the Surface Laboratory and some must be deployed to the surface while on Mars.

2.6.1 Requirements and Constraints

The requirements and constraints covered in Section 2.1 apply to landed science.

The following additional constraints and boundary conditions have been considered in the design of the landed science OSE.

1) The OSE design must emphasize flexibility in order to accommodate the fluid character of the experiment configurations
2) Assembly and test operations are performed in a clean atmosphere (Fed. Standard 209, Class 100,000 particulate requirements). The chances of biological contamination due to OSE or test operations must be minimized
3) The OSE should provide data for in-depth evaluation. This implies periods of continuous data collection on parallel test points.

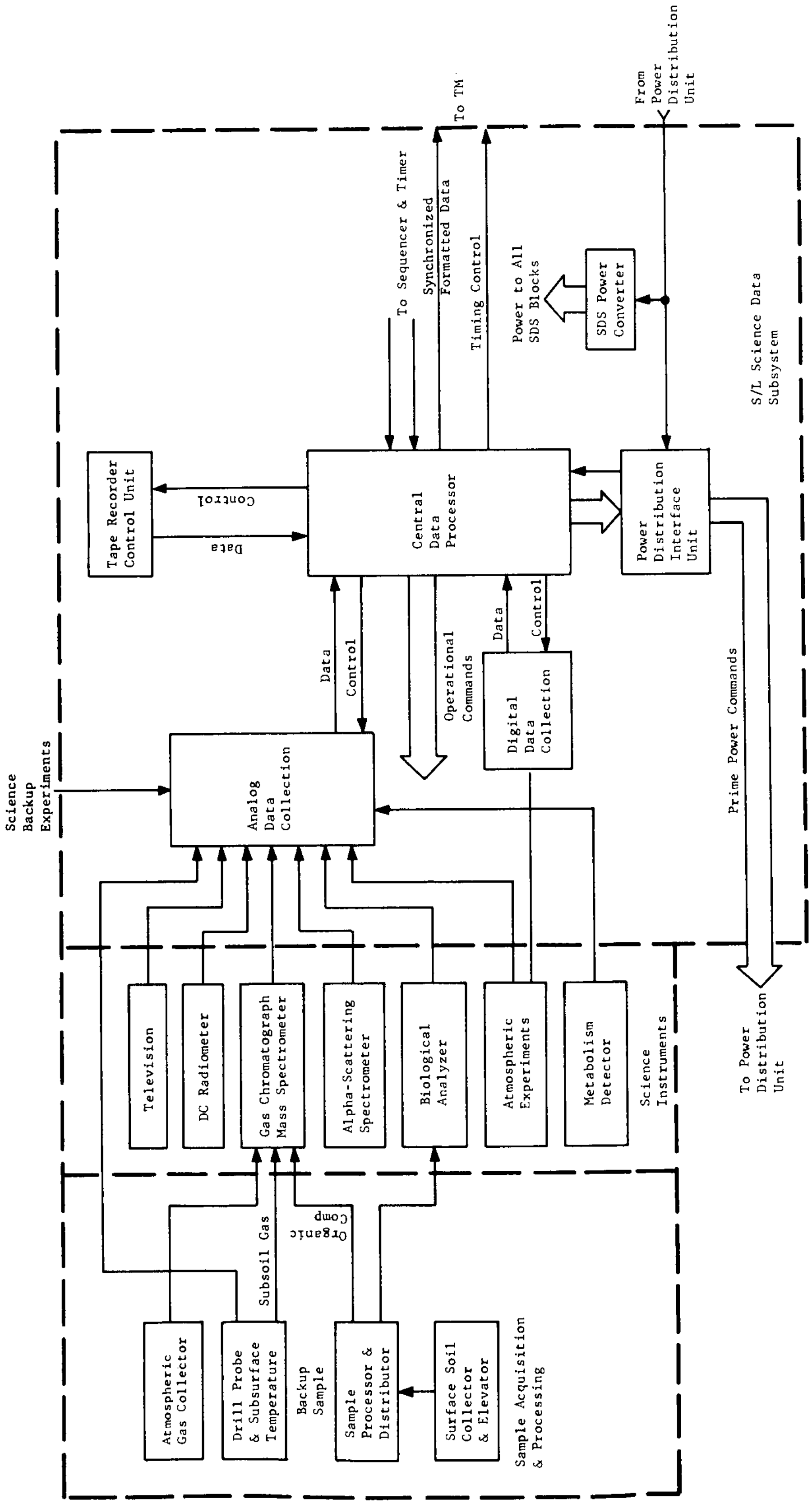


Fig. 2-8 Landed Science Subsystem, Block Diagram

The following are general activities or capabilities that all Surface Laboratory OSE provides:

1) All power required by the landed science subsystem, monitor all power lines, provide failure alarm and circuit protection means for setting main input voltages to high, medium or low levels
2) Test stand (and harness) simulating physical mounting of the subsystem in the S/L, including provisions for sample acquisition
3) Check running time of each test sequence. Provide time records of malfunctions and errors detected
4) Provide simulation of interfaces and control of self-test sequences to isolate trouble to the LSS.

2.6.2 Preferred Preliminary Design

The landed science subsystem OSE includes ten test sets that are required to test individual replacement level assemblies as well as the composite subsystem. Most of these test sets interface with a subsystem OSE computer system. Descriptions of each of these test sets are provided in the following paragraphs.

Visual Imaging Instrument Group Test Set - The visual imaging instrument group consists of two independent TV cameras with their matched electronics, plus a separate electronics unit. This unit supplies conditioned power, control and signal conditioning for both camera assemblies. The cameras vary their field of view with an electronic zoom circuit. Filters can be rotated in front of the lenses to change spectral characteristics of the camera inputs.

Requirements - The test set must be able to independently test as a functional entity, each of the three major assemblies as well as the instrument group.

The test requirements for the TV equipment that must be provided by the test station are:

Test	Test Level	
	Subsystem (Subcontractor)	Subsystem (System Contractor)
Transfer function	x	x
Response	x	x
Shading	x	x
Telemetry points	x	x
Test points	x	Partial
Resistance checks	x	-
Power	x	x
Geometric distortion	x	x
Optical and position alignment	x	x
Field of view	x	x

Telemetry data points and test points allow alignments and tests of sequence timing, deflection voltage alignment, focus current alignment, video amplifier gain, erase lamps, grid, filament and cathode voltage alignment, shutter operation, and beam current alignment.

Optical stimulation for the camera assembly requires black and white and colored targets and test patterns. Variable illumination levels are required for camera testing. Overall operation is checked from photographs.

Subsystem Definition - A simplified block diagram of the test set is shown in Fig. 2-9. The interface between the test equipment and the TV instrument group is the dotted line. Interface signals within the instrument group are interconnected through the switching arrangement in the test set to accommodate the various test configuration requirements.

The power equipment section includes instrument power sources as well as test-set power distributing and converting equipment. All dc power sources for the instruments are standard laboratory power supplies. Tests of the cameras independent of the other units require power sources simulating the TV electronic unit outputs. The instrument power equipment includes current and voltage monitoring capabilities to permit power-consumption tests. Protective devices preclude damage to either equipment.

The simulation and interface switching equipment section includes specially designed circuitry required to generate test signals, provide terminations for instrument outputs, and switch the interface lines.

Test signals include digital commands, camera commands and video simulation. Video signals are used for testing the video gain characteristics of the electronics assembly. The signal generator produces a pulse train with varying voltage levels that represents the normal video timing and pulse shape. Gain and frequency response characteristics of the TV electronics assembly are evaluated by a comparison of original and amplified signals on a standard oscilloscope.

The data processing and selection equipment includes specially designed equipment as well as standard instruments. The selection function selects individual test functions for display and recording. Data processing provides signal conditioning, normalizing, and amplification required to drive display devices.

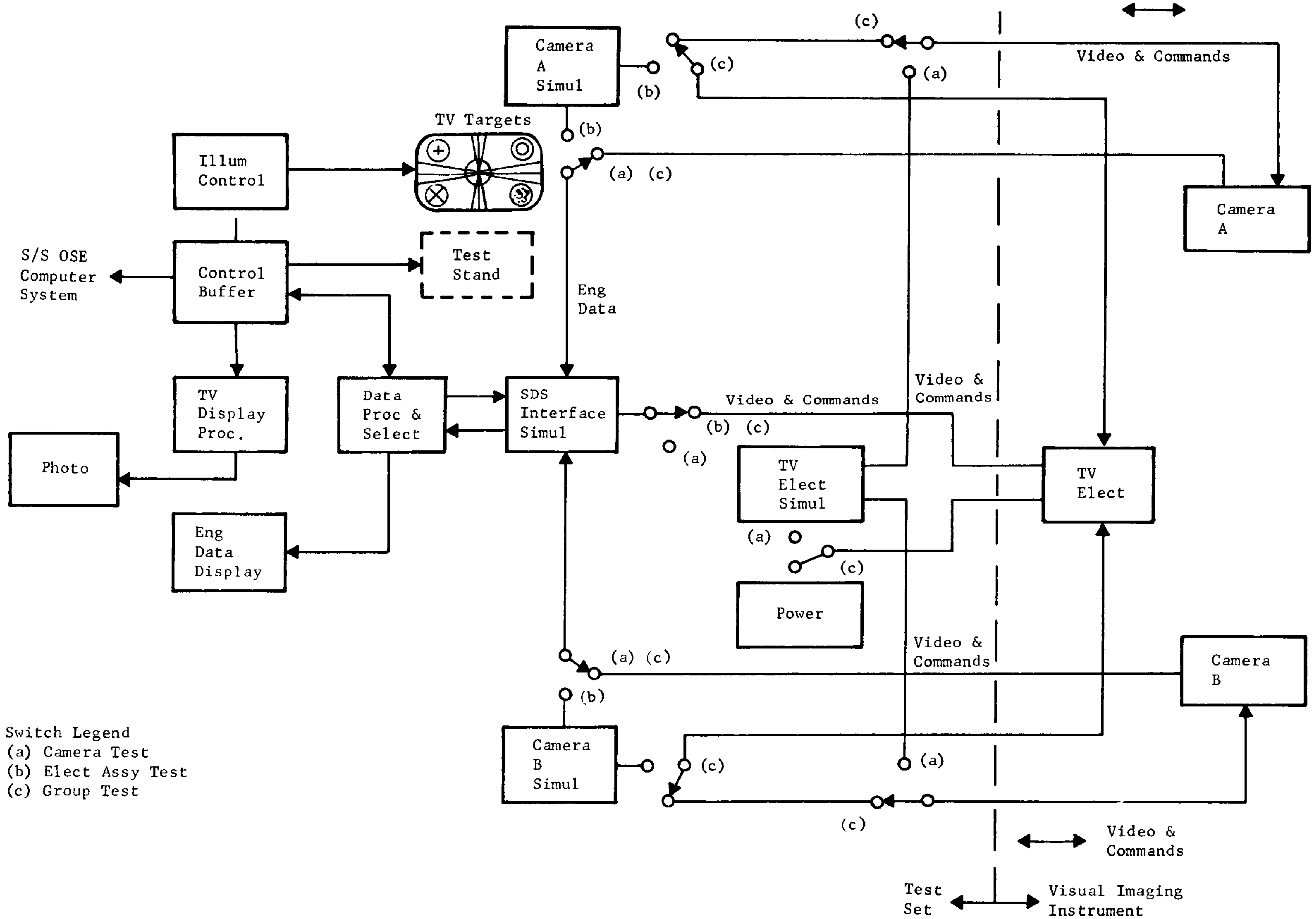


Fig. 2-9 Visual Imaging Instrument Group Test Set

The TV video data from the TV electronics unit are in pulsed analog form. These data are applied to common MDE-type display equipment.

The control and buffer equipment section includes the primary test control and panel and associated circuitry. It interfaces with all other test set sections for control. Test set and instrument test time totalizers are included in this section to supplement test log entries. The buffer unit is also housed in this panel and includes multiplexers and analog-to-digital converters for encoding data sent to the subsystem OSE computer system. It also includes the decoding and digital-to-analog converters for sending computer-originated stimulus signals to the TV equipment.

The display section includes all equipment required for display and recording test results. Specially designed display panels as well as precision standard laboratory instruments are required. Display devices include both analog and digital meters, an oscilloscope, and the TV display system. The TV display system uses the same equipment contemplated for the STC and MDE. Additional computer-driven displays and data printouts are provided in the standard computer test station.

Television test patterns and targets are placed in a collimator mounted on the prepared surface of the TV camera housing. Target illumination is controlled from the control section of the set.

Physical Characteristics - The TV test set consists of three bays of electronic equipment packaged in a single enclosure. Packaging and layout is illustrated in Fig. 2-10.

Interface Description - The visual imaging instrument test set interfaces with the instrument being tested, the standard subsystem OSE computer test station, and with facilities.

The interface with the instrument being tested includes dc power application, command and control signals, digital timing signals, analog video and engineering data signals. Mechanical and optical interfaces include the stimulation of the camera optics.

Interfaces with the subsystem OSE computer system involve digital control and data channels.

Facility interfaces include both power and space. Power required for the visual imaging test set is approximately 1.5 kw, 115 v, single phase at 60 Hz. Space required for the test set and associated optics is estimated to be 100 sq ft.

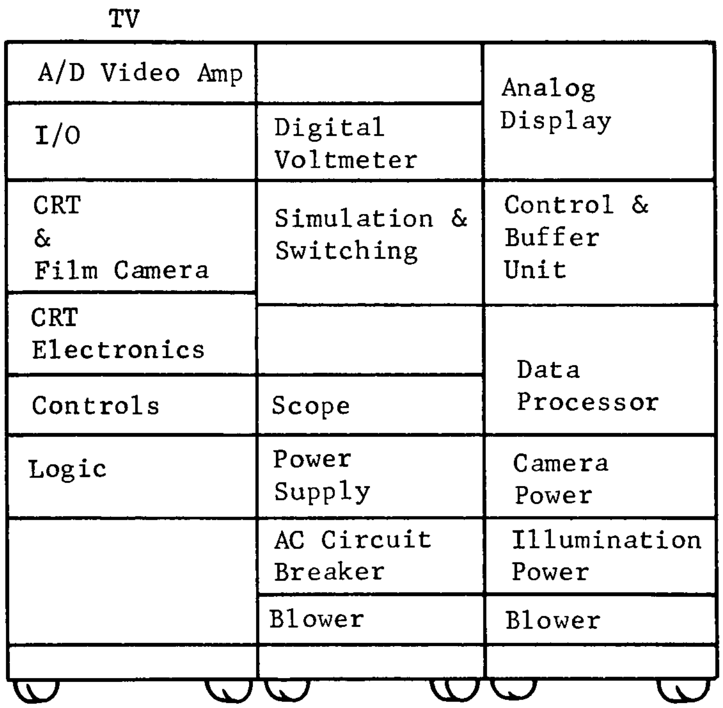


Fig. 2-10 Front Elevation, Visual Imaging Instrument Group Test Set

Molecular Composition Instrument Test Set - The molecular composition instrument is a single assembly including the gas chromatograph and mass spectrometer, associated pneumatics and power, control and signal conditioning electronics. The instrument accepts gaseous inputs from the sample acquisition and processing system, and provides spectral data to the science data system (SDS). Two pneumatic lines connect with the inlet ports of the instrument to feed it atmospheric and subsoil gas samples and pyrolysis gas samples for analysis. The power input includes a single 28-vdc source from the power distribution unit. Control signals from the SDS include typical commands such as power turn-on, mode selection, calibrate and readout, open inlet ports, scan control, and flush and recycle.

The gas chromatograph (GC) data line provides amplitude and time-senstitive analog data to the SDS. A typical scan length adequate to provide complete diffusion of the sample gas through the GC is about 10 to 20 minutes. The mass spectrometer data line also provides analog data to the SDS in multiple bursts. Individual scans of each sample provide a typical spectrum output signal.

Engineering data include scan synchronization signals, triggering information and general housekeeping information.

Requirements - The parameters tested during functional testing of the instrument include power consumption, pneumatic system leakage rate, response to commands, gas chromatograph response and accuracy, mass spectrometer response and accuracy, baseline calibration, engineering data output measurements, timing functions, GC scan time, MS scan time, temperature control and separator efficiency.

Functional testing of the instrument requires simulation of the electrical input signals, measurement and evaluation of output data, closure of certain sensing/control loops and stimulation of the instrument with known gas samples through sources typical of the pneumatic interface. In addition, certain pneumatic servicing functions are required such as charging the carrier gas supply, purging and cleaning the pneumatic system, and gas line leakage rate detection.

Subsystem Definition - A functional block diagram of the test set is shown in Fig. 2-11.

Gas test samples of soil pyrolysis gas and atmosphere and subsoil gases are supplied in storage tanks as shown. Individaul gases can be used or several gases can be mixed in the mixing manifold. The gas sources are supplied through regulator, valving and filter elements to the manifolds. A sample processor that simulates the SAP follows each manifold to condition the gas for use. Sensing of the sample condition is provided to notify the operator when the gas test can be started. The conditioned gas sample is then applied to the inlet ports of the instrument under test through regulation, metering, valving and filtering elements. A sample monitor fitting is provided near the interface for each test line. This fitting is used to provide a gas sample to a standard mass spectrometer test control. This operation is performed before issuing a sample to the instrument being tested and the results are sent to the computer system for comparison with the instrument data output.

A gas "standard" is used for general purging and calibration of the test system. It is identical to the carrier gas used in the molecular composition instrument. This source is also used for instrument servicing such as replenishment of the supply tank and general purging.

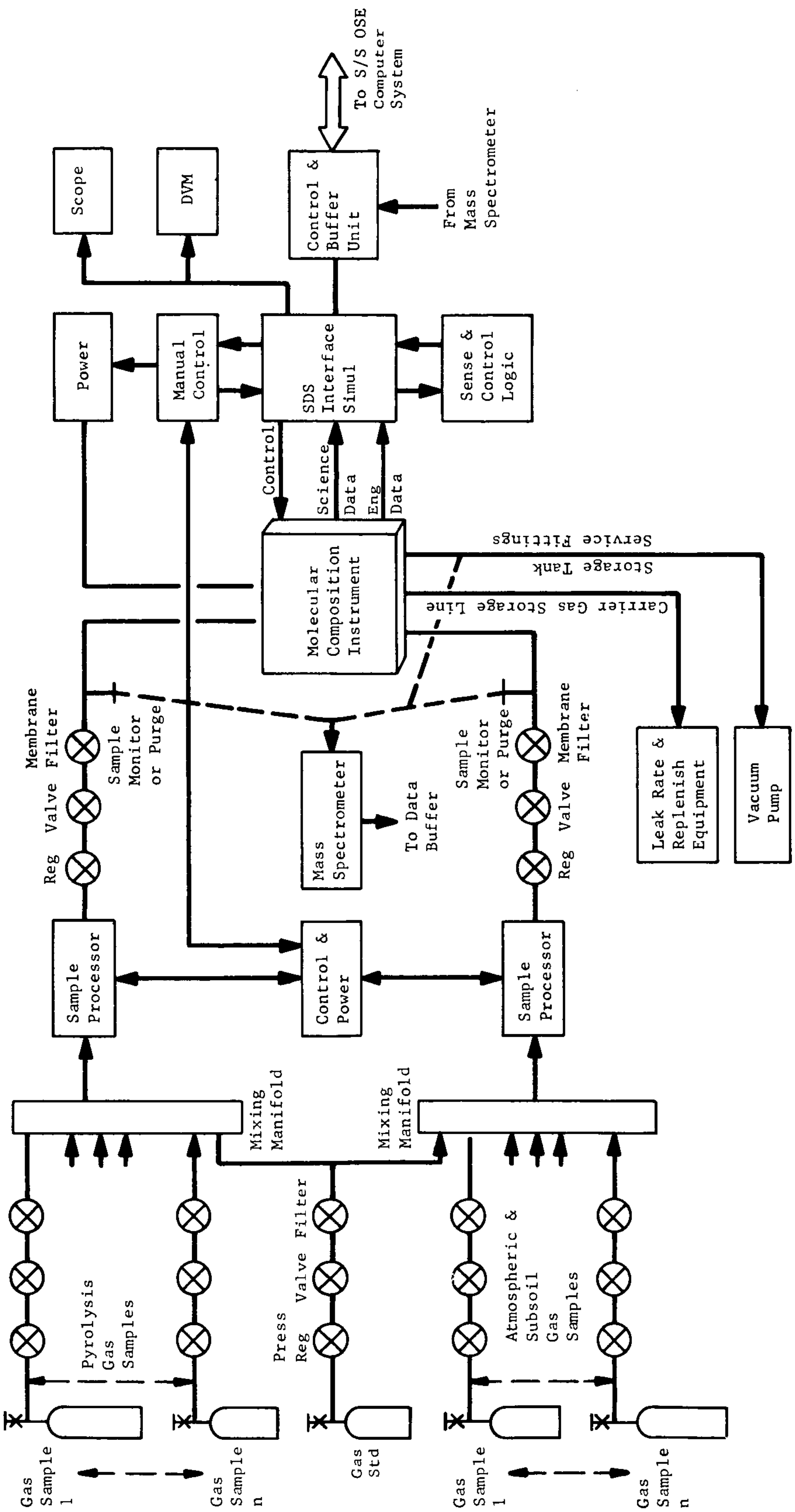


Fig. 2-11 Molecular Composition Instrument Test Set Functional Block Diagram

Leakage rate detection equipment attaches at the carrier gas supply fitting and is used to measure the integrity of the instrument gas system.

The efficiency of the instrument gas separator device is evaluated by connecting the test set mass spectrometer to the separator carrier gas discharge line. The separation efficiency can be measured by determining amounts of gases other than the carrier.

The vacuum pump is required to evacuate the instrument storage tanks after testing functions have been completed.

The electronic equipment section includes power control, test signal generation, data processing and display and recording functions.

Prime power is derived from a standard dc power supply and is distributed to the instrument through conditioning and protective circuitry.

Command and control signals are generated in the SDS interface simulator. Manual test control is provided from the test station control panel and associated circuitry. Closed-loop sensing and response critical to timing functions of the instrument are provided as a function of the SDS interface simulation equipment.

Science and engineering data signals are terminated in the SDS interface simulator with representative impedance matching circuits. The signals are then selected for analysis and applied to the data buffer for encoding and transmission to the subsystem OSE computer system where they are processed. Spectral data from the instrument are analyzed by the computer for amplitude-versus-time characteristics and compared with the reference data in memory.

Oscillographic recordings are also provided by computer equipment for additional analyses.

Timing measurements are required to check scan rates, scan start and stop triggering signals and timing between spectral outputs. These signals are also monitored for additional characteristics, such as wave shape and voltage level, to ensure compatibility with SDS logic circuits.

Physical Characteristics - The test set is composed of three major equipment assemblies. The special test equipment and pneumatic system are housed in three bays. A work shelf is attached to the assembly to accommodate the instrument under test. Figure 2-12 illustrates the conceptual configuration. Standard mass spectrometer and leak detection instruments are provided as physically separate equipment to allow flexibility in their use.

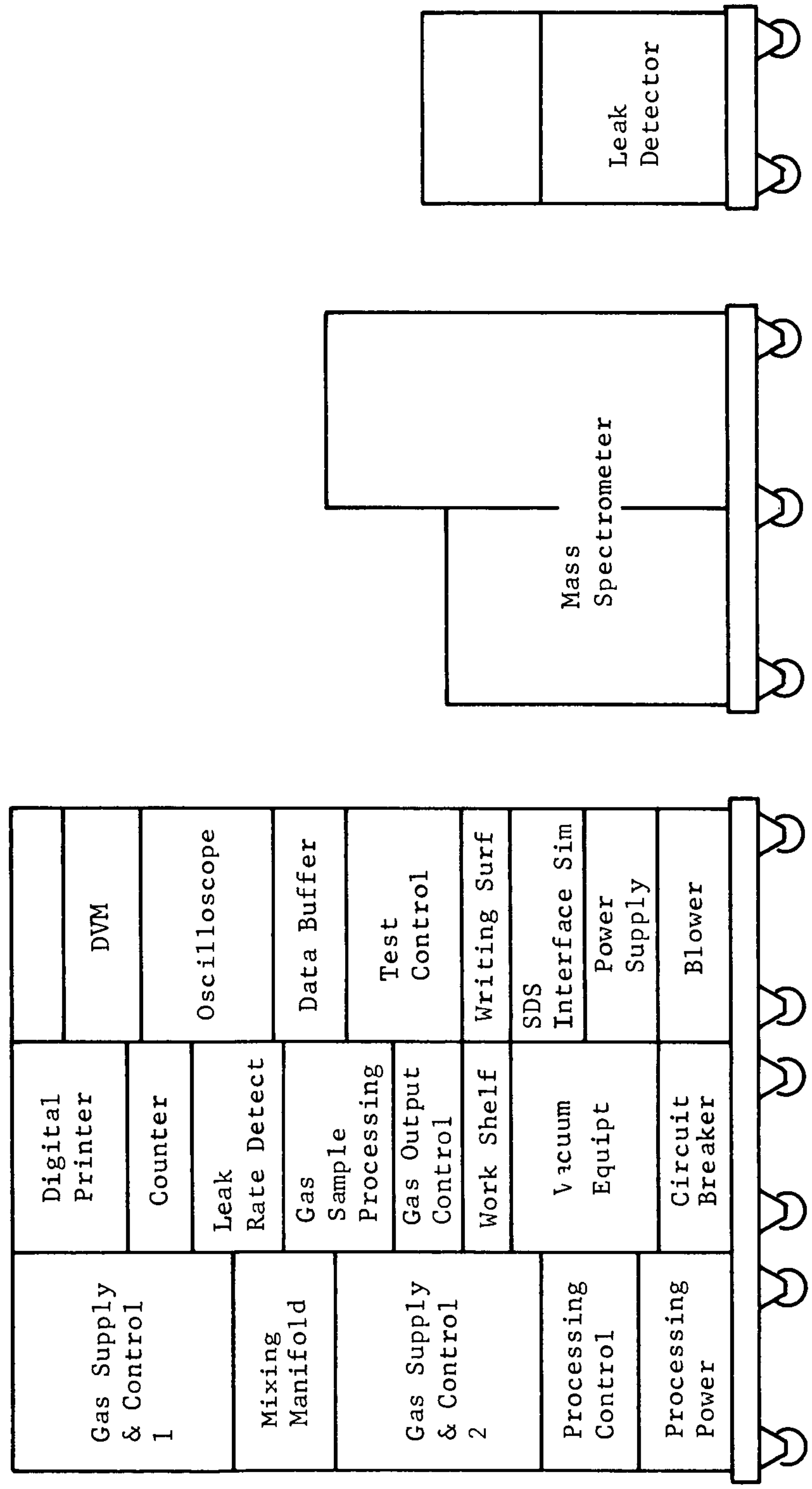


Fig. 2-12 Molecular Composition Instrument Test Set Rack Layout

Interface Description - The molecular composition instrument test set interfaces with the instrument being tested, the subsystem OSE computer system and facilities.

The instrument interface includes command and control signals, power application, engineering and science analog data and pneumatic equipment lines.

Digital data and digital control and display signals make up the major interface between the computer and the instrument test set.

Facilities include space requirements of approximately 100 sq ft and power requirements of about 1.5 kw of single-phase, 115-v service.

Solids Composition Instrument Test Set - The solids composition instrument consists of an alpha-scattering spectrometer and its associated electronics. The instrument is deployed to the Martian surface to bombard a soil sample with alpha particles. The output data are pulsed signals that are analyzed for level and distribution. These reaction products represent scattered alpha particles, protons, and characteristic X-rays.

The solids composition instrument receives 28 vdc from the power distribution unit. Control commands are received from the SDS and both engineering and scientific data are applied to the SDS for processing.

Control signals include:

1) Power turn-on
2) Initiate self-test pulse calibration
3) Remove radiation shield from alpha source. (This is a one-shot operation and requires a servicing operation to replace the shield in the storage position.)
4) Operate alpha spectrometer with the instrument cover plate. (This mode allows for bombardment of a known material and provides for a single-point check of instrument system function.)
5) Remove cover plate. (This is a one-shot operation in the normal mission and also requires a servicing operation to close it.)
6) Perform X-ray and proton measurement
7) Perform alpha and proton measurement

Scientific data are applied to the SDS interface on three outputs:

1) Proportional counter output for X-ray characteristics
2) Alpha particle detector output
3) Proton detector output.

Engineering data consist of internal dc voltage measurements and temperatures.

Requirements - Power consumption tests involve conventional techniques of monitoring and recording source current at varying voltage levels. Performance of other functions is also checked for adequacy at the extremes of input voltage.

Control signals are issued to the instrument from an interface simulator representative of the SDS output section. These are primarily digital on-off signals. Responses to the commands are measured in terms of engineering and scientific data outputs. Levels of command signals are manually variable to ensure operation of the instrument over the interface signal ranges.

Engineering data are terminated into impedance matching circuits typical of the SDS interface. Evaluation of the parameters is done by the subsystem OSE computer system.

Testing the instrument input/output transfer function is divided into two separate tests. First, all signals conditioning circuitry (except the preamplifiers) can be functionally exercised by operating the built-in calibration pulser. This unit supplies pulsed test signals to each of the input gate circuits as an independent self-test and a calibration of the output electronics. Variable control of the calibration pulser allows variations in repetition rate, pulse width, and pulse amplitude. This control feature is to be implemented by routing test lines to the interface connector. The test set is designed to be compatible and provides external control circuitry to vary these parameters. Measurement of response time, pulse shaping, gain, coincidence circuit operation, and linearity characteristics of each science data output line is thus enabled. The SDS simulator can terminate these control lines in fixed circuitry, such as a ground or fixed resistance to provide the nominal pulser calibration function.

The second test method involves end-to-end checkout. This test is more difficult to implement because if requires actuation of the alpha-source radiation shield as well as the cover plate and requires servicing after completion of the test. In addition, the section of the instrument containing the alpha source and detectors must be evacuated to eliminate absorption of the particles by atmospheric gases. This type of testing is required, however, to verify overall integrity of the source and detector/preamplifier circuitry, particularly before and after mechanical environment exposure. Response of the detectors and associated preamplifiers would be checked by using different target plates of predetermined characteristics.

Subsystem Definition - A functional block diagram of the test set is shown in Fig. 2-13. Direct current for the instrument is generated by a standard laboratory power supply with remote voltage control. Control and monitoring is in the test control panel. The power supply includes safety features such as short circuit protection and current limiting.

Commands for the instruments are manually initiated from the test control panel, conditioned in the SDS interface simulator, and applied to the instrument. The SDS interface simulator also includes proper terminating circuits for the data output lines. Data are fed in parallel to the data buffer where they are encoded, conditioned, and selected for subsequent processing by the subsystem OSE computer system.

Scientific data are applied to the computer for counting over a predetermined gate period. Pulse shape and amplitude are measured by the oscilloscope and may be recorded for permanent documentation by scope camera techniques.

Physical Characteristics - The test set for the solids composition instrument comprises both standard laboratory instruments and specially designed panels housed in a single two-bay enclosure (Fig. 2-14). A work shelf is attached to the side of the cabinet to provide the mechanical interface with the instrument. The vacuum chamber below the shelf allows evacuation of the instrument during end-to-end tests.

Interface Description - The test interfaces with the instrument under test involve command and control signals, engineering and scientific data outputs, power and mechanical plate stimulus.

Computer interfaces include digital data and digital control and display signals.

Facility interfaces include power requirements of approximately 1.5 kw, single phase, 115-v service and a space allocation of 60 sq ft.

<u>Solar Isolation Instrument Test Set</u> - The solar insolation instrument is an integral unit package, including collectors, detectors, and signal and power conditioning circuits. Basically, the instrument is a six-channel radiometer that measures the intensity of solar radiation, and supplies analog data relative to intensity in six individual wavelength bands.

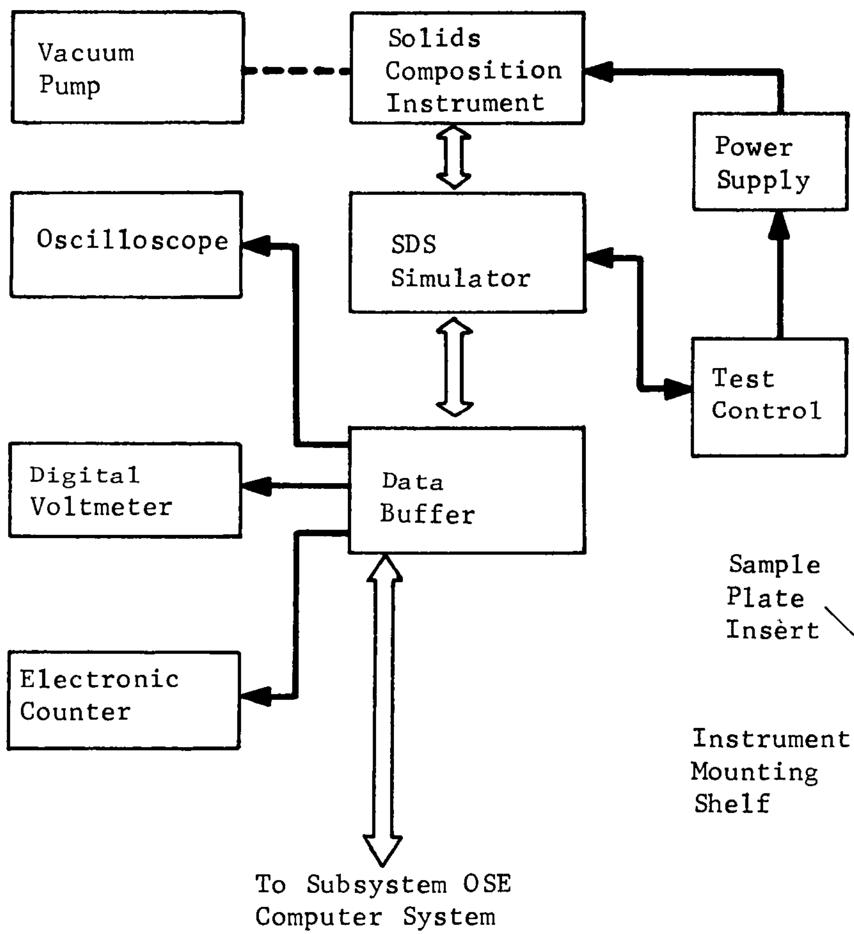


Fig. 2-13 Solids Composition Instrument Test Set

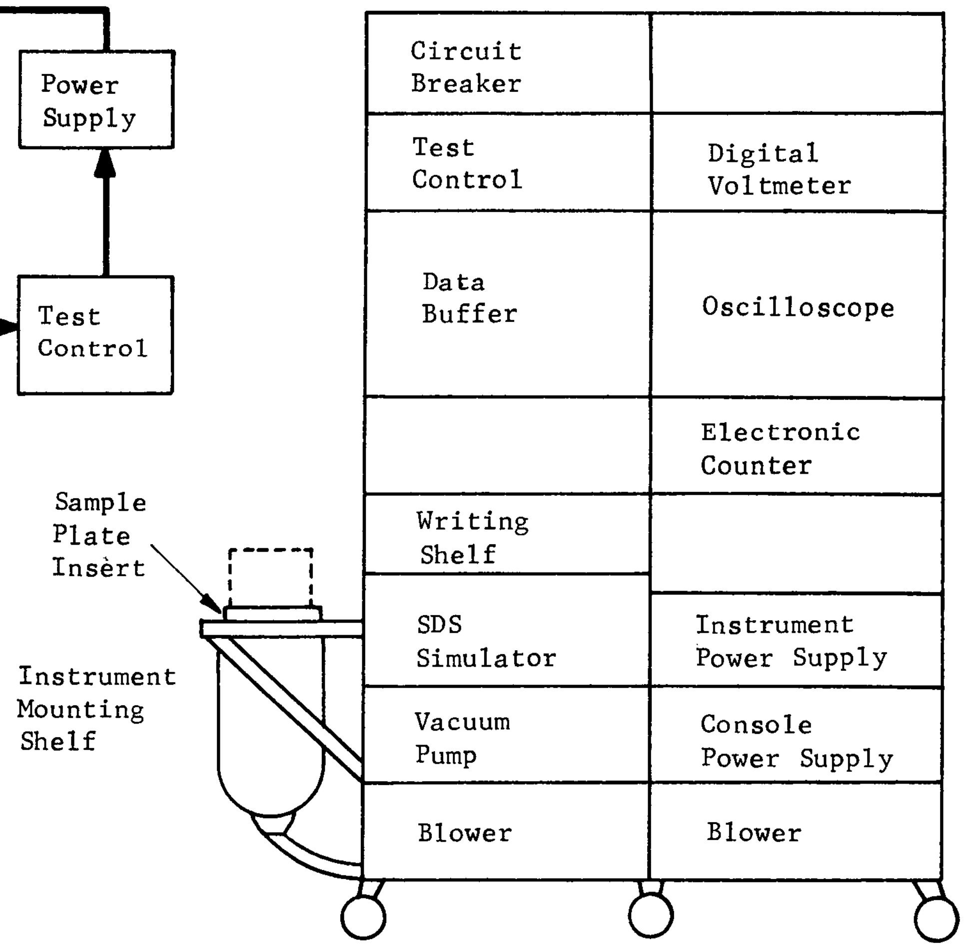


Fig. 2-14 Solids Composition Instrument Test Set Front Elevation

The instrument is mounted on the surface of the Surface Laboratory with collectors exposed to solar radiation. Functional interfaces include dc power supplied from the Surface Laboratory power distribution unit, and control and data lines interconnecting the instrument and the SDS. Thermal control is required to minimize effects of thermal changes on the detector characteristics. Six output channels carry scientific data relative to specific spectral bands and terminate in the SDS for subsequent coding. Commands are simple turn-on control signals for initial power and light-chopper motor operation. Engineering data include temperatures and converter output voltages.

Requirements - Prime power is supplied to the instrument at varying voltage levels representing the limits of the power supplied in the Surface Laboratory System. Current and voltage monitoring provides power consumption data. Monitoring of engineering data output signals, particularly converter outputs, checks the performance of the instrument over the power input operating range.

Commands are issued from special test circuits representative of the SDS interface. Output characteristics noted in engineering and scientific data lines provide test data verifying the correct instrument response.

Engineering data are terminated in correct impedances simulating the SDS interface. Measurements are made by the digital measuring equipment in the test set and evaluated in the subsystem OSE computer system.

The dark condition of the solar insolation instrument is checked by installing a cap over the instrument collector surface and measuring the science and engineering data output levels. This information is typical of calibration data expected to be provided during inflight testing.

The instrument is stimulated by a variable-intensity solar-simulator illuminator. The data outputs representing solar intensity and spectral band location are compared with the known inputs to get calibration data. The dc outputs from the instrument are processed by the subsystem OSE computer and can be recorded on strip charts, if required. Overall performance accuracy is obtained from science data outputs adjusted, if necessary, with thermal output information.

Subsystem Definition - The functional block diagram of the test set is shown in Fig. 2-15.

The test control panel includes specially designed circuits required to initiate instrument control signals, control power supply voltages, select output data for the specific display, and control the illuminator unit.

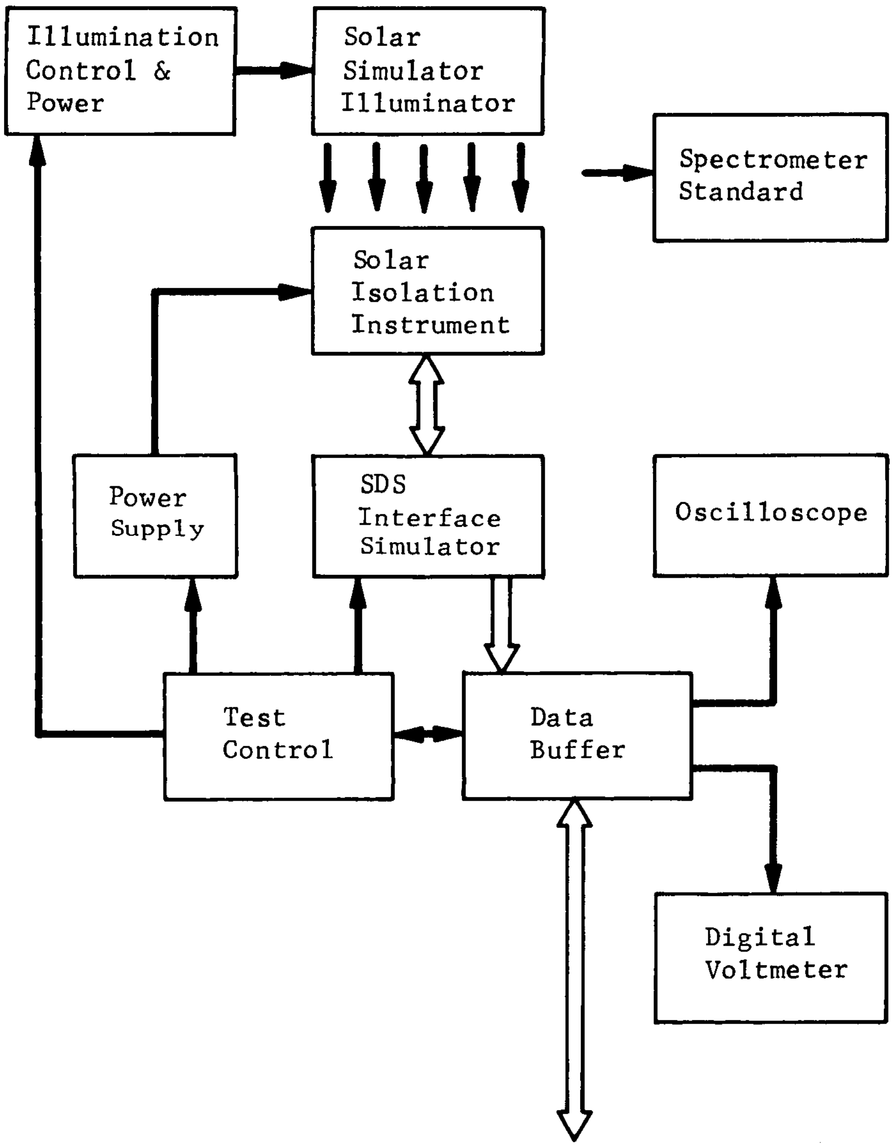


Fig. 2-15 Solar Isolation Test Set

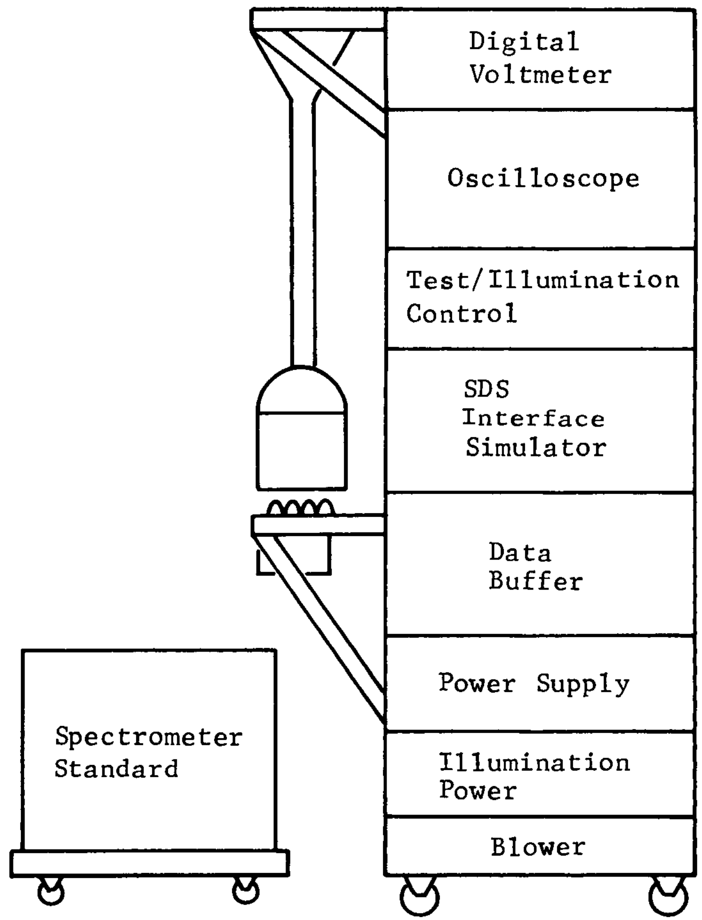


Fig. 2-16 Rack Layout of Solar Insolation Test Set

The SDS interface simulator includes circuitry to condition the command signals for application to the instrument. Signal terminations are also built into this unit to provide simulation of the SDS impedance characteristics. Data output signals are selected, encoded, and conditioned in the data buffer for subsequent application and processing in the OSE computer system. The oscilloscope is used to monitor the quality of science data outputs as well as for general-purpose application.

The power supply is a remotely controlled variable voltage source providing the required dc input for the instrument under test. Output circuits provide short circuit and current overload protection.

The illuminator is a specially designed configuration including a solar simulation illuminator. The device is a hat-like unit that fits down on the work shelf around the instrument. Calibration standards of the intensity and spectral characteristics of the illumination are provided by a standard laboratory spectrometer.

Physical Characteristics - Figure 2-16 illustrates the packaging concept for the test set, which consists of a single bay containing the test equipment. A work shelf that provides the instrument-holding fixture is attached to the side of the cabinet. The illuminator assembly is above the instrument and can be raised or lowered to accommodate installation of the instrument and subsequent stimulation. The spectrometer is separated from the main console to allow for multiple use.

Interface Description - The test set/instrument interface includes power application, control signals, and engineering and scientific output data. The optical interface includes the solar simulation illumination.

Interfaces between the subsystem OSE computer system and the test set include digital control and display signals as well as digital data.

Facility power requirements are approximately 2 kw, single phase, 115-v. Space required for the test set is approximately 60 sq ft.

<u>Atmospheric Instrument Test Set</u> - The atmospheric experiment instruments consist of the sensors and their electronics. The sensors are mounted on booms that deploy the sensors a short distance above and to the side of the Surface Laboratory. Two sets of sensors are operated independently. They share a single electronics unit.

The design of the instrumentation includes five replaceable assemblies:

1) Platinum resistance thermometer
2) Diaphragm pressure transducer with capacitive pickoff
3) Aluminum oxide humidity sensor
4) Sonic anemometer
5) Central atmospheric experiment electronics assembly.

Requirements - The test set must accomplish the following functional tests:

1) Calibration of each sensor with the central electronics
2) Testing over the environmental range
3) Testing for input power regulation effects
4) Checking for mutual interaction effects, including electromagnetic susceptibility and interference
5) Independent testing of the central electronics assembly by simulation of sensor interfaces
6) Checking all engineering parameters provided by the design.

Performance of each instrument is checked at nominal and high and low limits of input primary voltage, to establish any degradation of performance, including calibration inaccuracy, resulting from power regulation.

At some point in the test sequence, the complete set of instruments is operated simultaneously to verify mutual compatibility.

Subsystem Definitions - Figure 2-17 is a functional block diagram of the test set.

The control and buffer unit routes primary power from the power supply and timed control signals from the subsystem OSE computer system to the instruments in the environmental chamber, which has its own controls.

Both sciencific and engineering data from the instruments and from the environmental sensors are routed to the patching and switching unit. These outputs can be measured and analyzed on the general-purpose test equipment -- an electric counter, an oscilloscope and a digital voltmeter.

The power supply provides an adjustment of primary power to 28 v, and to both the high and low specification limits, e.g., 32 and 24 v for checking performance under conditions of poor power regulation and for determining the possible effects on calibration.

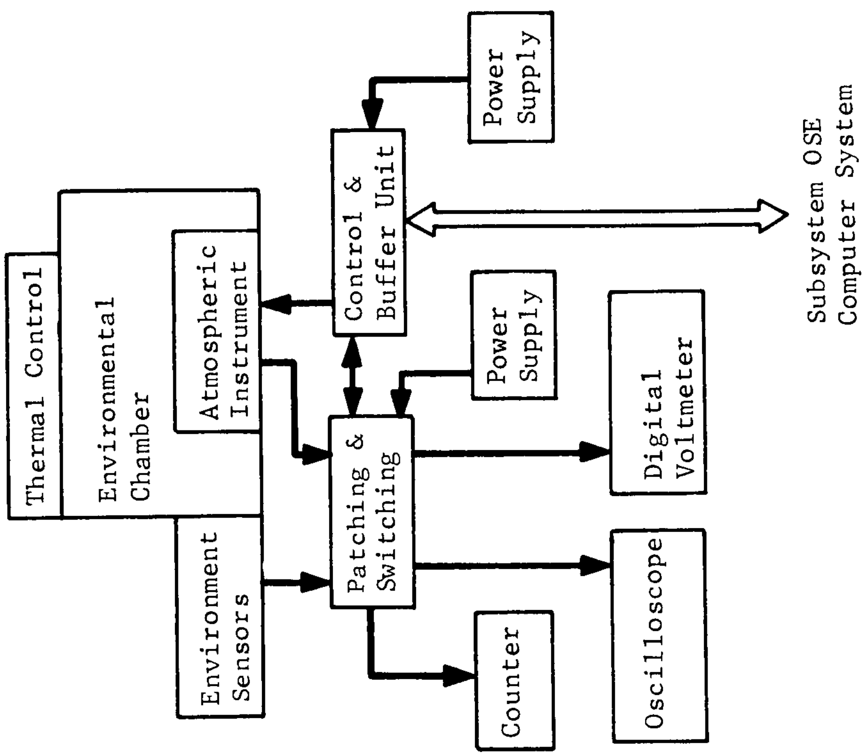


Fig. 2-17 Atmospheric Instrument Test Set Diagram

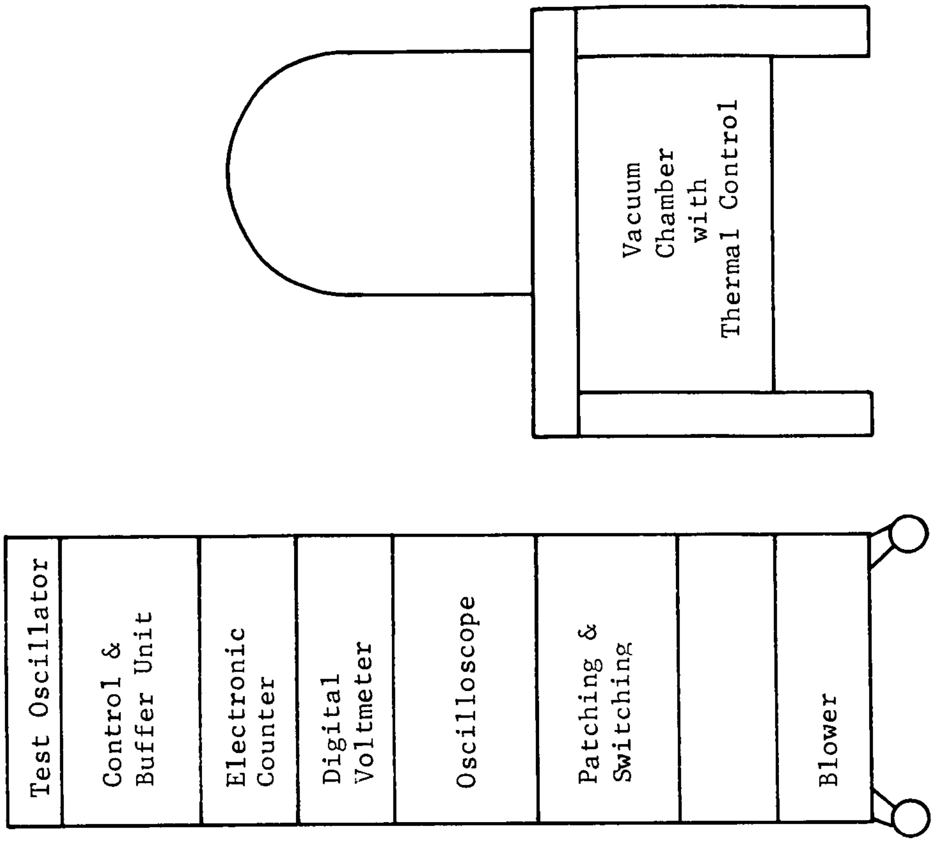


Fig. 2-18 Atmospheric Instrument Test Set Front Elevation

The test oscillator provides signals required for subassembly testing.

The standard subsystem OSE computer test station includes the discrete and digital displays and keyboard control for automated testing.

Physical Characteristics - The test set rack layout is shown in Fig. 2-18. All the standard test equipment, the power supply and the control and buffer unit are accommodated in a single standard rack.

The test set includes a vacuum chamber equipped with thermal plates, with heating and cooling provisions, a means of injecting controlled amounts of water vapor, and standard gages for temperature, pressure, and humidity. The vacuum chamber can accommodate all the instruments simultaneously, to minimize the time loss in pump-down and stabilization cycles and to permit testing for mutual electromagnetic interference, both radiated and conducted.

The fixtures for mounting the instruments in the environmental chamber provide efficient coupling to the thermal plates. A device to create an air current is installed on the fixture with the sonic anemometer.

Controls and pumps for the environmental chamber are under the bench on which the chamber rests.

A self-contained blower cools the equipment rack.

Interface Description - The proposed test set includes the ability to simulate all the interfaces of the atmospheric instrumentation, including the Martian environment.

The OSE interfaces include:

1) Facility power - 115 vac, 60 Hz, 1.6 kw from facility power mains, converted to 24 to 32 vdc for the atmospheric electronics unit and special voltages for the OSE. Space required for the test set is approximately 65 sq ft
2) Control and data interface with the subsystem OSE computer system for automatic sequencing of tests, and for acquisition, analysis, display and recording of data. Analog, digital and discrete data acquired from the instruments and from the OSE are processed by the control and buffer unit and routed to the subsystem OSE computer. The computer provides discrete control signals through the control and buffer unit for both instruments and OSE
3) Control and data interface with the instruments under test.

Biological Analyzer Test Set - The biological analyzer includes two optical/biochemical experiments -- an ultraviolet (UV) spectrophotometry assay and an optical rotary dispersion assay. It is a very complex electronic, optical, and electromechanical device with an involved sequence of operations.

The analyzer's major components are:

1) A sample wheel with 24 chambers that is used to deliver soil sample solutions into an optical compartment. The wheel can be stepped or spun at rates that provide good centrifuging action
2) Optical equipment including a light source, a collimator, polarizer, UV filters and photo detector
3) Electromechanical equipment including mode wheel drive, mode wheel, drive motor, magnetic drum, and recorder head
4) Pressurization unit
5) Temperature control unit
6) Necessary electronics for programing, conditioning, and processing.

Requirements - The test set performs the following functions:

1) Checks all mechanical operations
2) Verifies capability of sequence and mode control by external source
3) Verifies calibration of instrument; i.e., ability to identify presence of organic compounds
4) Verifies mode and status indicator outputs
5) Verifies validity and repeatability of science data outputs
6) Tests performance under variations of input power
7) Checks all engineering data outputs for validity
8) Verifies functioning of built-in test provisions.

The test set includes provisions for checking optical alignment in each mode and adequacy of light intensity. Similarly, when active samples are analyzed, provisions must be made for cleaning, filter replacement, and recharging with solvent.

At some stage of integration it will become impractical to exercise the biological analyzer with active samples because access for purging and recharging will be precluded. At this point, built-in test provisions become essential.

The built-in test, using specific chambers preloaded with test samples, permits conducting all the above operations except the sample preparation. It verifies the performance of the light source, optics, and data processing, while leaving the instrument ready to accept samples in the mission mode.

When an environmental simulation is required, the test chamber described for the atmospheric instrument test set is employed.

Subsystem Definitions - Figure 2-19 is a functional block diagram of the biological analyzer test set.

The control and buffer unit switches primary power and relays computer control to the biological analyzer.

The power supply provides an output, nominally 28 vdc, programed also for the specification limits, 24 to 32v.

The sample acquisition and processing (SAP) simulator provides soil samples as required for functional testing.

The biological analyzer status data are routed through the control and buffer unit. All analog data, both scientific and engineering are routed to the patching and switching unit for local analysis, as well as to the control and buffer unit for encoding and transmission to the subsystem OSE computer system for processing.

The patching and switching unit permits use of the digital voltmeter and oscilloscope for troubleshooting and for optical alignment operations.

The standard subsystem OSE computer test station provides keyboard control of testing and display sequences and local data displays.

Physical Characteristics - The test set rack layout is shown in Fig. 2-20. The standard test equipment, power supply, and control and buffer unit are mounted in a single equipment rack.

A small bench is provided for mounting the SAP simulator and the biological analyzer under test.

Interface Description - The OSE interfaces include:

1) Facility power - 115 vac, 60 Hz, 0.9 kw, from facility mains, converted in the OSE to 28 vdc (4 vdc) for use by the biological analyzer. Space required for the test set is approximately 60 sq ft.
2) Data
    a) Digital data from the biological analyzer, representing coded status (mode and step data) to the subsystem OSE computer system
    b) Discrete and digital data from the subsystem OSE computer system to the biological analyzer
3) Analog scientific and engineering data from the biological analyzer to the patching and switching unit for local display and analysis, or routing through the control and buffer unit for encoding and transmission to the subsystem OSE computer system for analysis, display, and recording.

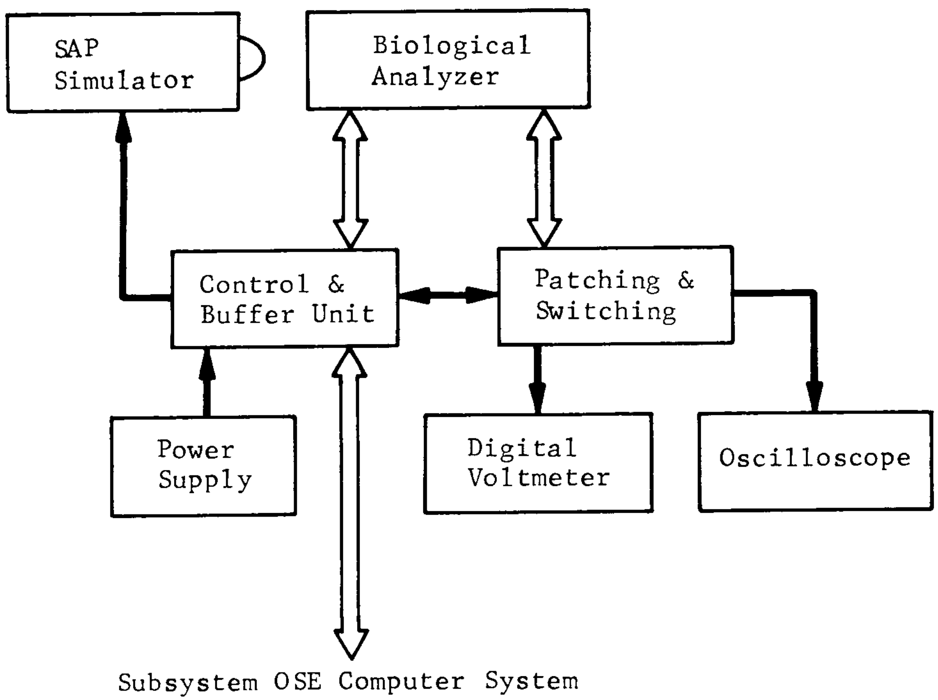


Fig. 2-19 Biological Analyzer Test Set

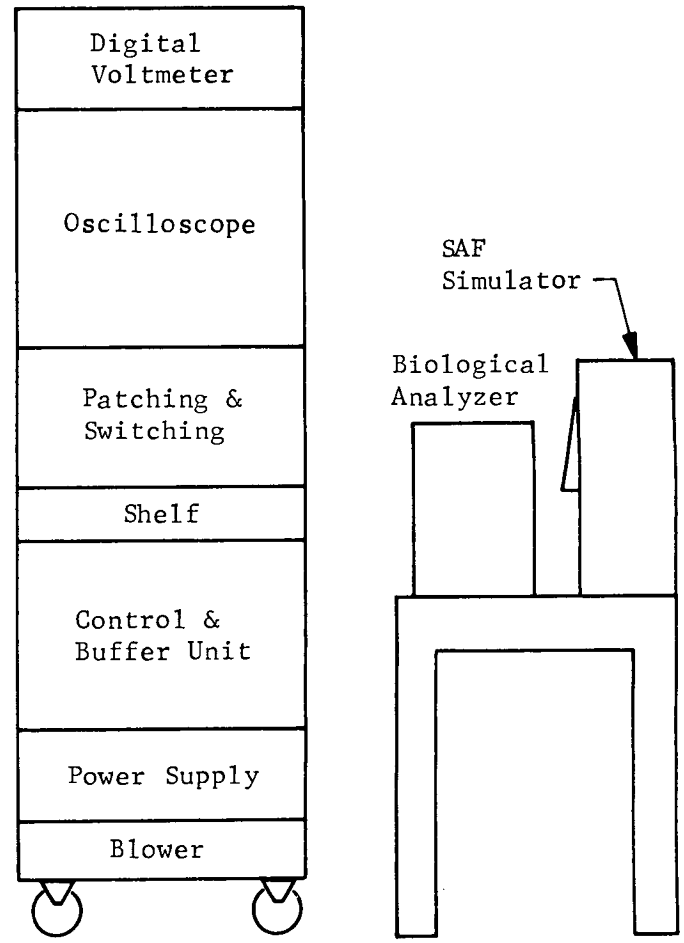


Fig. 2-20 Biological Analyzer Test Set
Front Elevation

Metabolism Detector Test Set - The metabolism detector equipment comprises two deployable detector units, one active and one control, and a common electronics unit. The mass spectrometer detector head, in both the active and the control units, is immediately above a transparent hood that is placed on the Martian surface. The detector continuously samples environmental gases that slowly leak into the evacuated instrument. Heating coils are provided to clear ice from the inlet ports. A vacuum line is provided to pump down both units. The mass spectrometers are normally programed to monitor specific atomic mass channels. They are also capable of operating in a full scan mode.

Requirements - For all tests except type approval and flight acceptance, it is assumed that an electromechanical substrate discharger will be substituted for the pyrotechnic, in the interests of safety.

The test set must include provisions for cleaning and decontaminating the detectors after any testing requiring substrate discharge.

Internal functional tests required include:

1) Power conditioning unit performance, including total power consumption
2) Vacuum pump operation
3) Electrical heater circuitry performance
4) Mode selection response
5) Scanner control and output level checks
6) Spectrometer performance
7) Amplifier gain and linearity
8) Processor transfer functions
9) Total performance effects of input power variation.

Any functional tests of the metabolism detector require enclosure of the deployable heads in an evacuated chamber. When this is necessary, the most practical configuration places the electronics unit in the chamber as well.

Subsystem Definitions - Figure 2-21 is a functional block diagram of the metabolism detector test set.

The Control and Buffer Unit switches power (28 v) to the metabolism detector, provides mode control from the subsystem OSE computer system and triggers the substrate dischargers to initiate testing. All control functions are manually backed up.

Science data, in analog form, from the metabolism detector are routed to the control and buffer unit for switching the oscilloscope or the digital voltmeter at the discretion of the operator, as well as for encoding and transmission to the subsystem OSE computer system for analysis, display and recording.

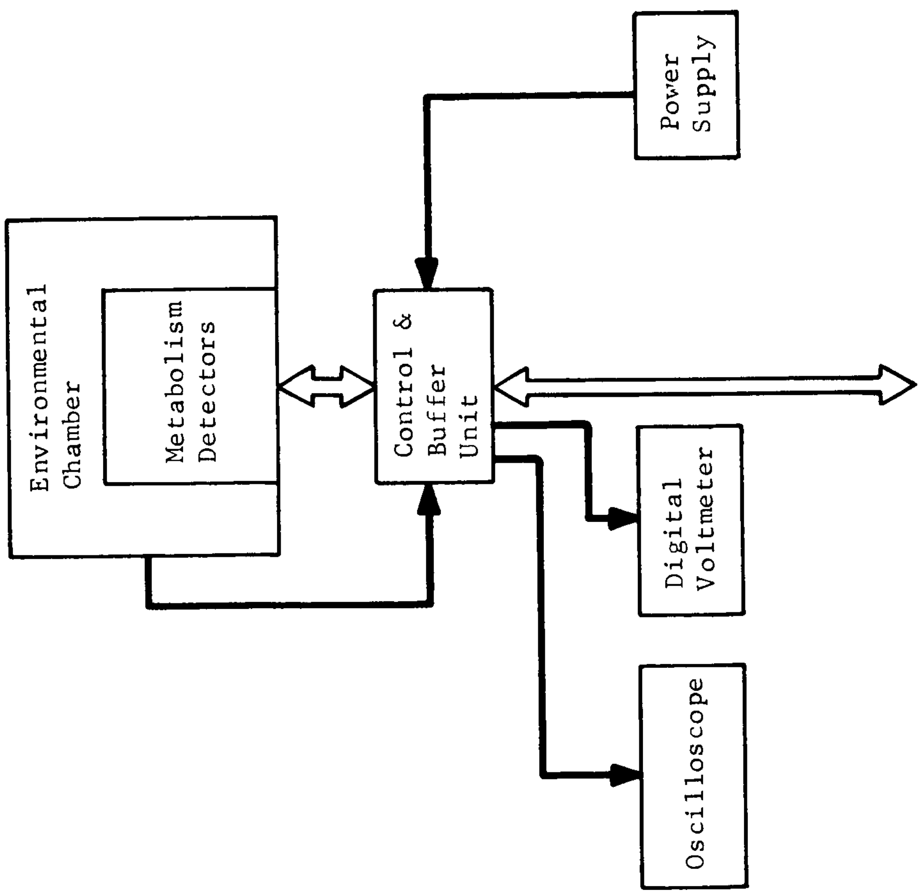


Fig. 2-21 Metabolism Detector Test Set Diagram

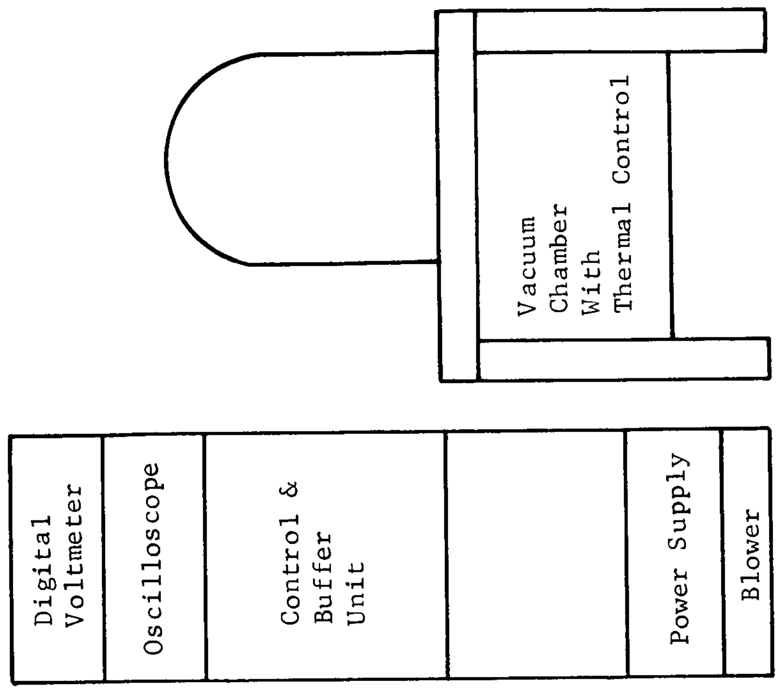


Fig. 2-22 Metabolism Detector Test Set Rack Layout

Engineering data, including outputs of the environmental sensors, are brought through the control and buffer unit for selective measurement by the commercial test equipment and transfer to the computer.

The test chamber, with its own controls, simulates the Martian environment for the metabolism detector test.

The standard test equipment (oscilloscope and digital voltmeter) is used for troubleshooting and alignment testing.

The subsystem OSE computer test station provides keyboard control of test sequences and display of discrete and digital data.

The power supply provides an adjustable dc voltage, nominally 28 v, for the metabolism detector.

Physical Characteristics - A tentative layout of the metabolism detector test set is shown in Fig. 2-22.

The general-purpose test equipment (oscilloscope and digital voltmeter) is housed in a single rack with the power supply and the control and buffer unit.

The environmental chamber with its control unit is adjacent to the rack.

Interface Description - The OSE has the following major interfaces:

1) Facility power - 115 vac, 60 cps, 0.9 kw, converted in the power supply to 28 vdc for the metabolism detector. Space required for the test set is approximately 65 sq ft
2) Control - Coded control signals from the subsystem OSE computer system to the control and buffer unit, converted to discrete controls for OSE and metabolism detector. Digital data signals from the test set to the subsystem OSE computer for analysis and recording.

Science Data Subsystem OSE - The SDS equipment to be tested by this OSE comprises the following major functional units:

1) Data processor
2) Data collection unit
3) Power distribution unit
4) Tape recorder unit
5) Power converter.

The key element of the SDS is the data processor. This unit accepts incoming signals from the central sequencer, the command decoder, and the Spacecraft, and provides all control signals to the science instruments and the SAP.

Data from the experiments are routed to the data collection unit. Data then come into the data processor, in digital form where they are analyzed, temporarily stored, and put on the tape recorder for later transmission, or sent on to the telemetry subsystem during transmission periods.

The tape recorder unit is also used to store auxiliary operational programs for the central data processor, which may be recalled by ground command.

The power converter unit provides all operating voltages required by the SDS. The power distribution unit provides power to all science instruments and the SAP.

The SDS interfaces include:

1) Control signals to the science instruments and SAP
2) Digital and analog data from the instruments and SAP
3) Control signals from the central sequencer
4) Control signals from the command decoder
5) Reprograming signal interface with the command decoder
6) Distribution of landed science subsystem power
7) Input power to SDS from the Surface Laboratory power subsystem
8) Time synchronization from the central (master) time code generator
9) Analog data from science backup sensors and engineering measurement devices.

Requirements - In addition to the SDS interfaces, the following internal SDS functions must be checked by the SDS OSE:

1) Formatting data for telemetering
2) Sampling, conditioning, and reduction of data
3) Sequencing science operations
4) Storage and processing TV data
5) Buffer storage of telemetry data
6) Sequencing and control of instrument and SAP power
7) Performance under varying input power conditions
8) Adequacy of engineering measurements.

The OSE must also be able to troubleshoot the SDS, case of malfunction, to the replaceable subassembly level, and to verify performance after a spare unit is installed.

It must also be able to verify the calibration of counters and analog-to-digital converters, and determine bit error rate in processing TV data.

Interface compatibility is verified by electrical simulation, providing full range variation. For example, a 5-bit parallel digital interface would require introduction of ones and zeroes on each of five lines. Analog channels require a test voltage at each anticipated extreme and at least one intermediate value.

Reprograming tests include both loading programs from the SDS tape and discrete program changes through the simulated command decoder interface.

Power requirement of the SDS is determined for each mode of operation, and its performance is checked at both high and low specification limits of input voltage.

All engineering data provided by SDS sensors are monitored continually during tests and periodically checked for validity.

Each data word is verified for processing accuracy and for correct position in the format. Science data subsystem (SDS) data reduction and processing functions are verified by introduction of test problems typical of mission inputs.

Discrete events under SDS control are noted and timed, and the intervals between sequence events are compared against design values.

Bit error rates for processing a TV data frame and for typical instrument data formats are established by ones-count techniques.

Built-in calibration provisions are verified by external means.

Subsystem Definitions - Figure 2-23 is a functional block diagram of the SDS OSE.

The OSE provides primary power for the SDS through the power unit. The power control and monitor monitors input current making the data available for analysis and recording. The test mode and step are determined by the operator at the subsystem OSE computer test station.

Environment sensors make available, for recording, the test conditions.

The signal conditioning and switching unit comprises a series of interface units (TM interface, direct-access electronics, analog multiplex and conditioner, and signal simulation) providing for transfer of digital data to the control and buffer unit. The control and buffer unit provides the coding, decoding, and buffering necessary for interface compatibility between the SDS and the subsystem OSE computer.

The subsystem OSE computer system processes all data flowing between the computer and the SDS-OSE. Discrete displays on the subsystem OSE test station indicate the test mode and step, and occurrence of significant events.

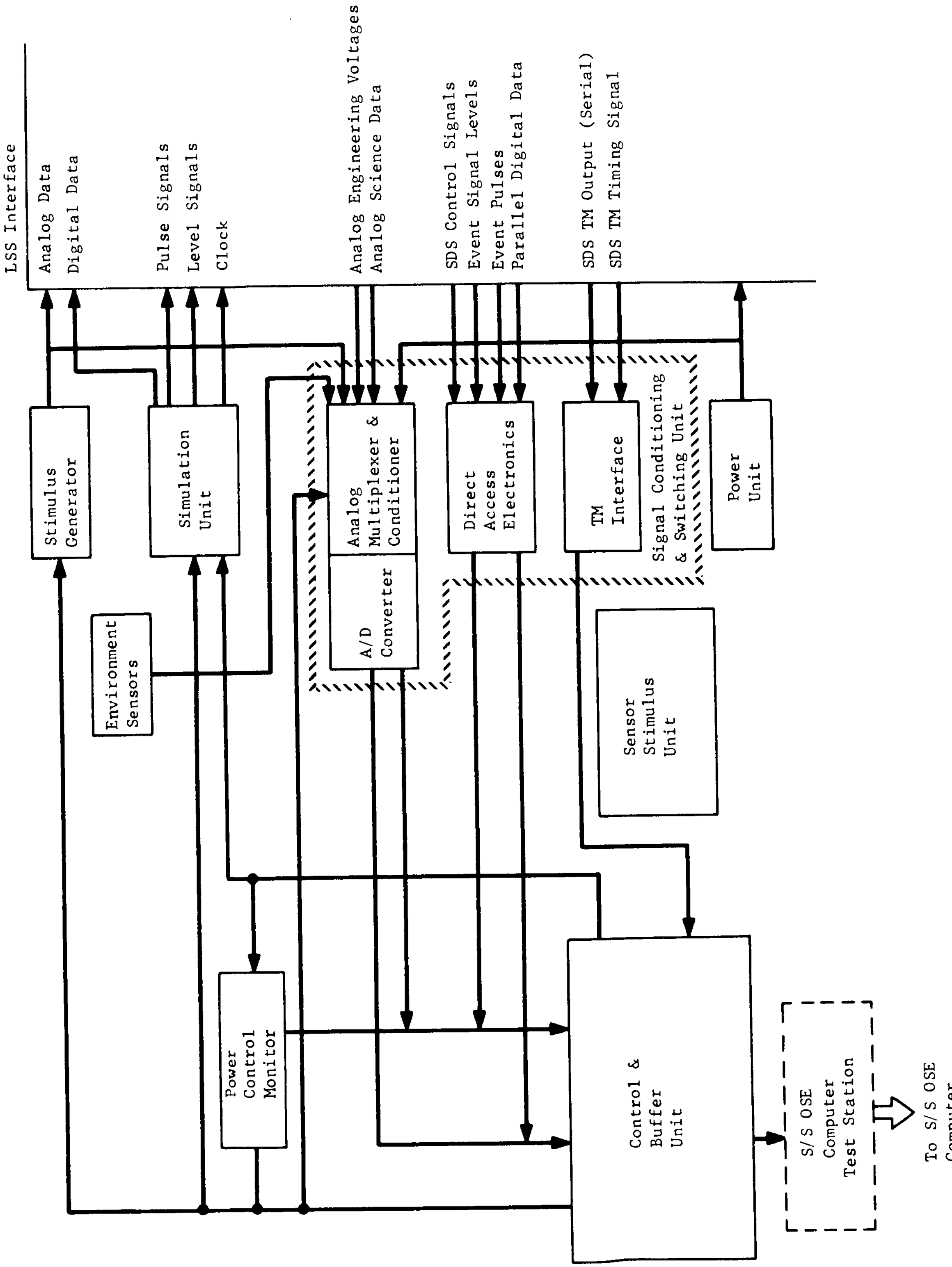


Fig. 2-23 Science Data Subsystem Functional Block Diagram

The general-purpose test equipment (digital voltmeter and oscilloscope) are used with the direct-access electronics for troubleshooting.

Physical Characteristics - Figure 2-24 is a rack layout of the SDS OSE.

The standard test equipment, power supply and monitor, signal conditioning and switching unit, and control and buffer unit are housed in three standard racks.

Interface Description - The principal interfaces of the OSE include:

1) Facility power - 120 vac, 60 cps, 1.3 kw converted in the power supply to 28 vdc for the SDS. Space requirements for the test set are approximately 75 sq ft
2) Control - Coded signals from the subsystem OSE computer system to the control and buffer unit for sampling, sequencing and signal simulation, test mode, step control, and data call-up
3) Data - Discrete, analog and digital data from the SDS and analog data from environmental sensors to the test set.

Sample Acquisition and Processing Subsystem OSE - The sample acquisition and processing system (SAP) acquires soil samples and distributes them to the biological analyzer. It also acquires gas samples from the Martian atmosphere, from Martian subsoil and from pyrolyzed surface soil and delivers them to the gas chromatograph.

The SAP is composed of five principal subassemblies: Atmospheric gas collector, surface soil collector (acquisition) and transport, subsoil gas collector and temperature probe, soil processing and distribution, and the deployment mechanism for the surface collectors.

The functional interfaces of the SAP include:

1) Control signals from the SDS for:
    a) Deployment mechanism operation
    b) Release of atmospheric gas collector value
    c) Drill motor operation
    d) Subsoil gas valve operation
    e) Subsoil gas pump operation
    f) Surface scraper operation
    g) Elevator drive operation
    h) Soil screening operation
    i) Metering valve operation

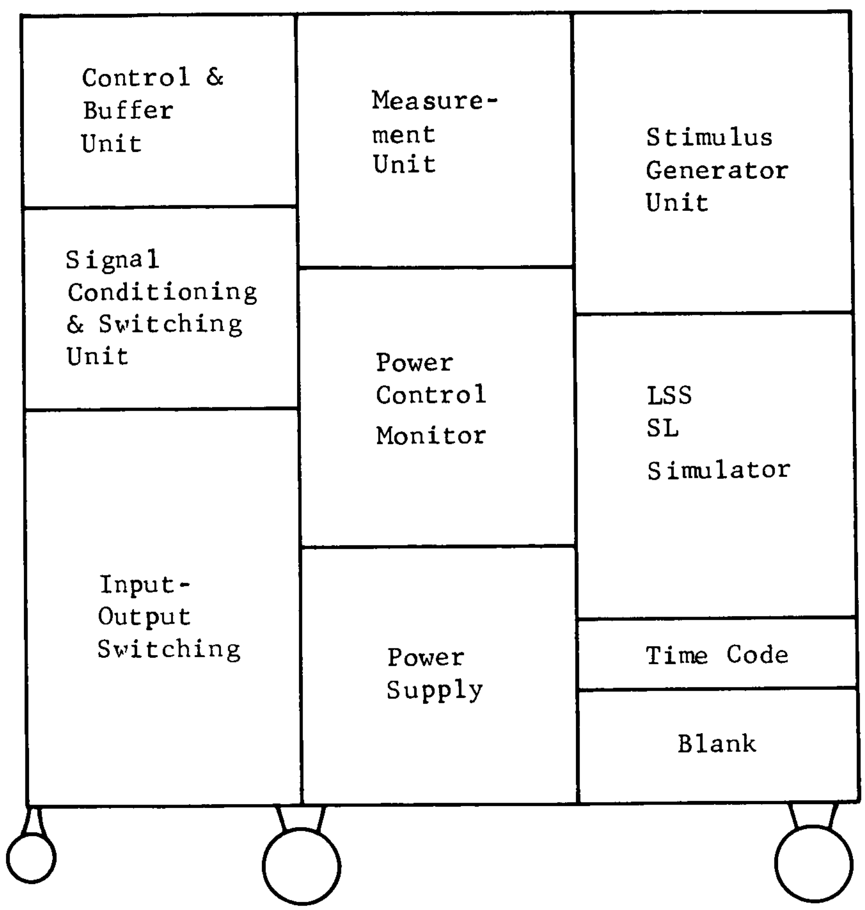


Fig. 2-24 Front Elevation Science Data Subsystem Test Set

j) Oven heater operation

k) Oven piston operation

2) Power input from power distribution unit of SDS

3) Pneumatic interfaces with the gas chromatograph for delivery of gas samples

4) Mechanical interface with the biological analyzer for delivery of soil samples

5) Mechanical interface with the Surface Laboratory structure for mounting the SAP.

Requirements - In addition to checking interface compatibility, the OSE must be capable of checking:

1) SAP functions (defined in 1 above) in response to SDS control signals

2) Status and engineering data outputs of the SAP

3) Power consumption in each operating mode

4) Performance under conditions of varying input power

5) Sample delivery capability.

The OSE must be capable of isolating trouble to the malfunctioning subassembly and verifying performance after replacement or repair of the defective part. A general-purpose environmental chamber is employed to simulate the Martian environment.

Tests that might cause excessive degradation of moving parts (such as drilling) are only performed as needed. If additional demonstrations are required, soft, nonabrasive material will be used to simulate Martian soil. In all cases, biologically passive soil samples are used unless the tests can be followed by thorough cleaning of the soil sample equipment.

Tests are sequenced by the subsystem OSE computer system. Processing, recording, and display of data are sychronized with test operations to ensure that pertinent parameters are available for review.

Power consumption is continuously monitored and current peaks are recorded. Input power is varied between the voltage specifications limits to check performance under these conditions.

Pneumatic interfaces are checked by introducing typical differential pressures and recording flow rates.

All discrete status, analog, and engineering data are displayed or recorded.

Delivery of soil samples on command is checked visually, possibly supported supported by gravity-actuated electrical switches.

Subsystem Definition - The functions of the test set are illustrated in block diagram in Fig 2-25.

The control and buffer unit accepts 28 vdc from the power supply and switches it appropriately to the SAP. Programed initiation signals are also supplied by the control and buffer unit, simulating the functions of the SDS. These functions can be supplied manually or under computer control from the subsystem OSE computer system.

Discrete status data from the SAP are routed by the control and buffer unit to the control and display panel for operator information and to the data buffer unit for transmission to the subsystem OSE computer for processing.

Analog engineering data are also routed by the control and buffer unit to the display panel and routed to the computer.

Physical Characteristics: The SAP OSE rack layout is shown in Fig. 2-26. The special equipment is housed in a single bay. During the test sequence, the SAP equipment is fastened to the work area as illustrated.

Interface Description - The interface between the SAP and the test set includes analog data and digital control signals, power application, and pneumatic lines. A mechanical interface is involved in the soil sample during exercising of the drill and probe equipment.

Digital control data signals make up the interface between the test set and the computer.

Landed Science Subsystem OSE - This OSE performs detailed testing of the landed science subsystem (LSS) as a separate test function. In this configuration all system interface connections must be supplied by the test set. In addition, direct access connections are made to the internal control and data lines to permit the detailed testing necessary to isolate troubles to the assembly level.

the LSS comprises the SDS, SAP and all the experiment instrumentation, including TV.

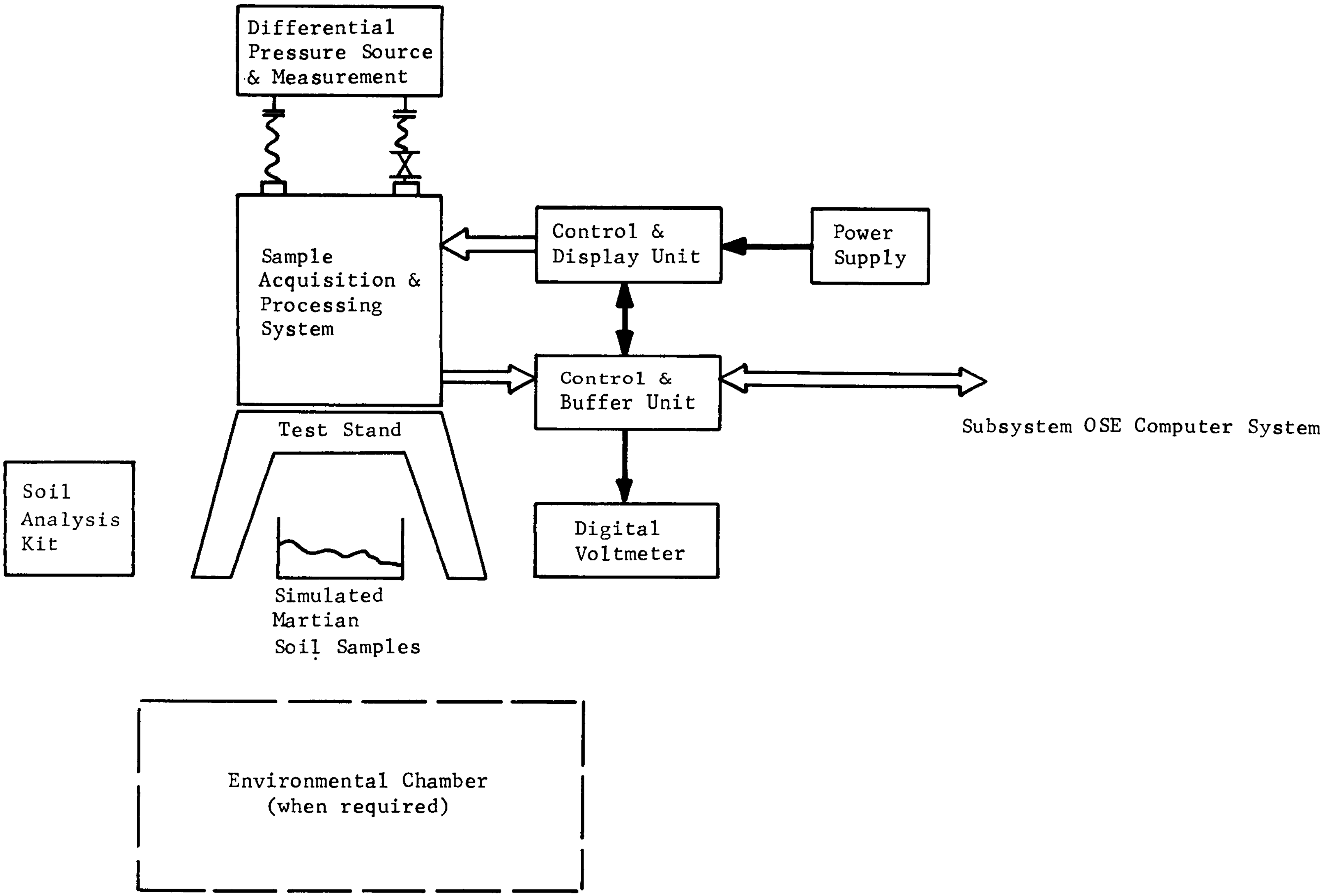


Fig. 2-25 Sample Acquisition & Processing Test Set Diagram

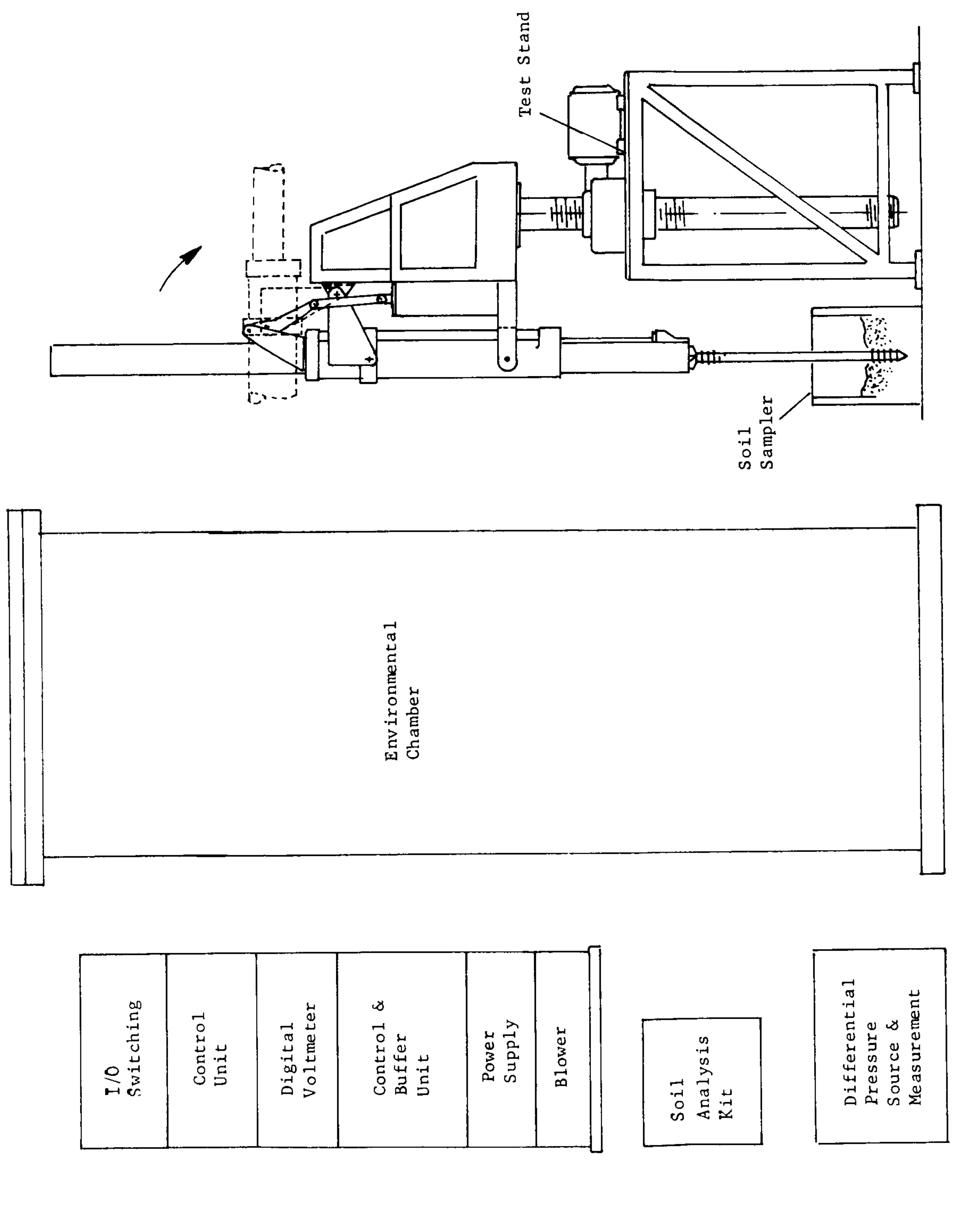


Fig. 2-26 SAP Test Set Rack Layout

Subsystem Description - Figure 2-27 indicates the computer-controlled subsystem test configuration. Central control of the system is achieved by execution of stored programs in the subsystem OSE computer core memory. The computer provides command-word instructions to the LSS OSE to control signal generation, conditioning and switching of discrete, digital and analog stimuli to the LSS. Discrete, analog, and digital data from the LSS are signal conditioned, encoded and buffered in the LSS OSE for transmission to the subsystem OSE computer where they are stored, processed and evaluated. Significant test results are printed out and time tagged. These test results may indicate a need for branching to subroutines for more detailed test and analysis.

The LSS OSE provides the signal conversion and conditioning equipment required to implement computer program instruction. Landed science subsystem (LSS) interface signals with the Surface Laboratory are simulated and response signals through the data automation system (DAS) are monitored and compared for compatibility with applied stimulus levels. Similarly, experiment sensors are stimulated and compared with the known stimuli. Sample acquisition and processing (SAP) equipment is activated and performance verified under conditions approximating mission sequences. Control of simulated mission sequences is exercised through the DAS central data processor by application of simulated Surface Laboratory sequencer signals. Central data processor recorders and memory storage capabilities are verified through digital loading and verification circuitry in the LSS OSE. The data automation system central data processor backup sequencing functions are exercised and verified.

Telemetry data channels are monitored and compared with supplemental discrete and analog monitors, which provide intermediate test point data for comparison.

Television equipment is checked and calibrated by monitoring known test patterns and by verifying the quality of telemetered data.

Completion of testing at the assembled subsystem level is prerequisite to integration of the landed science equipment into the Surface Laboratory System.

Physical Characteristics - Figure 2-28 shows a tentative rack layout for the LSS OSE.

The general-purpose test equipment, the power supply and its monitor, and the control and buffer unit are housed in four standard racks.

The sensor stimulus unit is mobile and includes all the special-purpose items required to exercise the LSS.

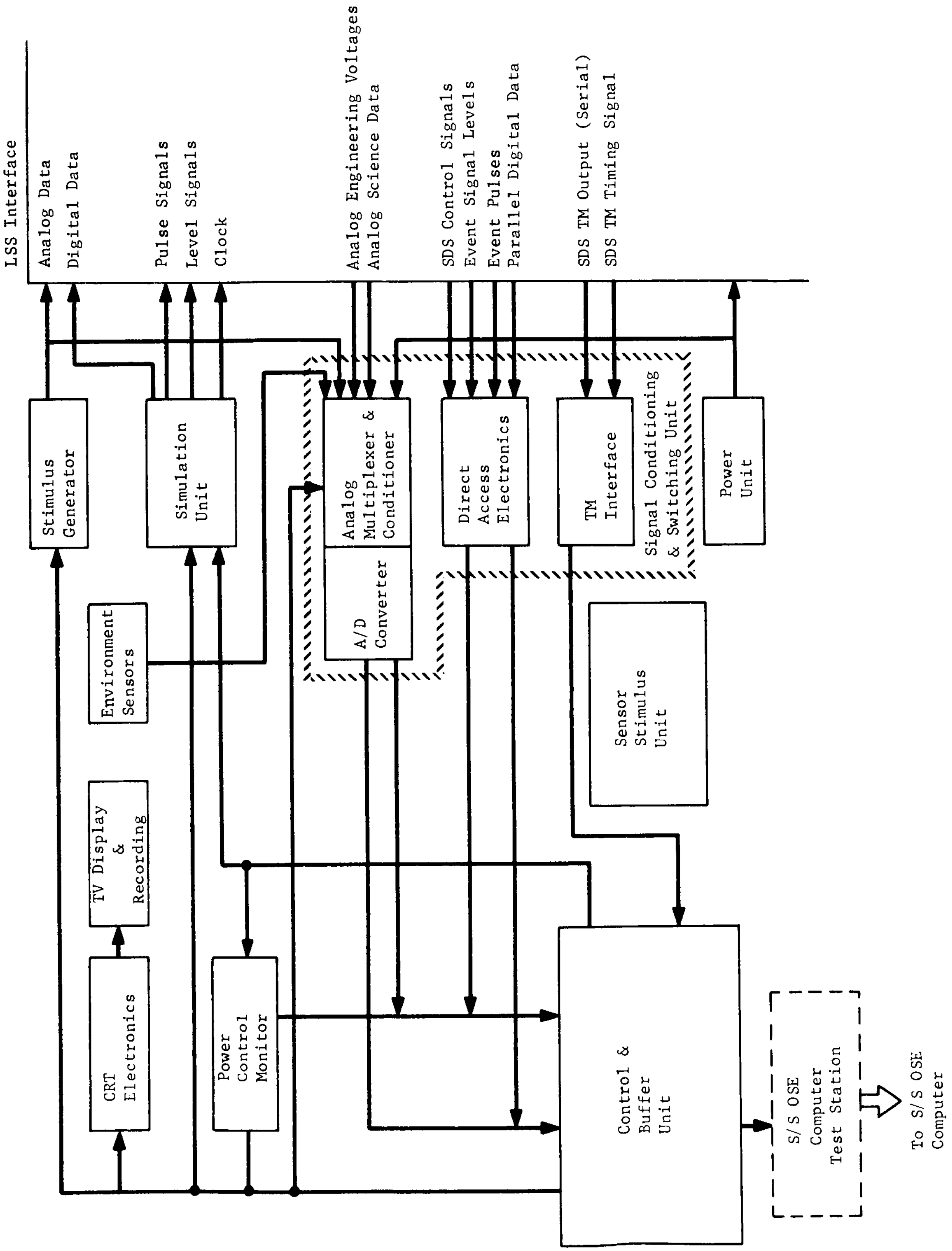


Fig. 2-27 Landed Science Subsystem Test Set Functional Block Diagram

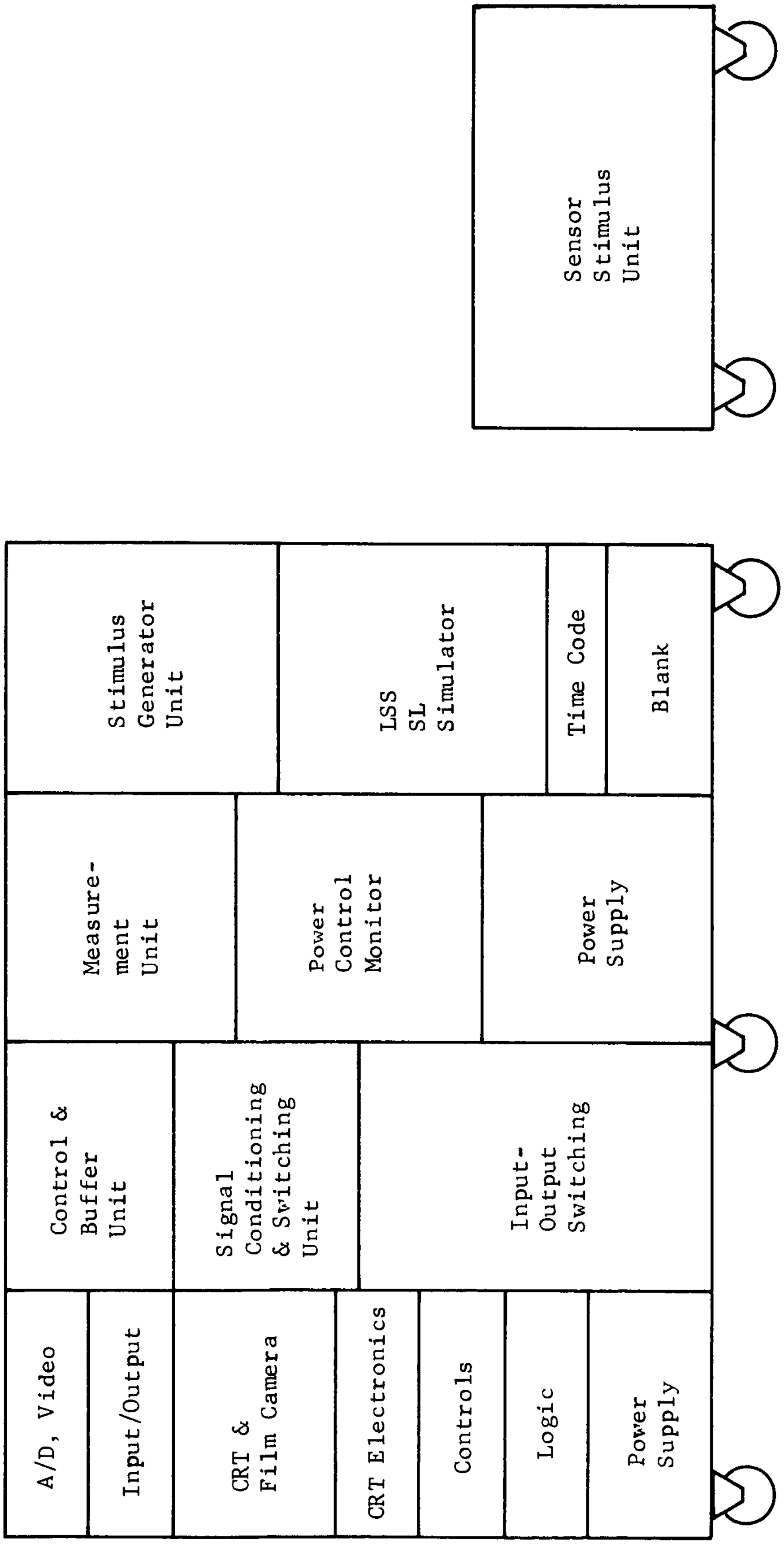


Fig. 2-28 Landed Science Subsystem Test Set

Interface Description - The test set interfaces with landed science subsystem (LSS) consist of command and control signals, engineering and scientific data outputs, power and unique experiment sensor stimuli.

Computer interfaces are digitized data, control and display signals.

Facility interfaces include power requirements of approximately 2.5 kw of single phase, 115-v service and 100 sq ft.

2.6.3 Subsystem Analyses and Trade Studies

The selection of a preferred approach was made between two concepts:

1) Special-purpose test sets for each of the major components of the landed science subsystem
2) A general-purpose test set that checks all functions of the landed science subsystem.

The decision involves careful consideration of:

1) Sterilization qualification levels
2) Type-approval levels
3) Replaceable spare levels
4) Field calibration requirements
5) System integration flow
6) Level of functional checkout and performance testing required at each stage of integration
7) Assembly and test schedule requirements.

Assuming an equivalent functional capability for each of the two alternatives, the preferred approach is determined by the various test levels required to qualify this subsystem. Because the subsystem consists of so many individual experiment packages that are to be developed and tested by separate and widely scattered subcontractor organizations, the use of individual experiment-oriented test sets appears mandatory. To attempt to design a single test set with total checkout capability and provide it for individual experiment tests is economically unfeasible. The special-purpose nature of the experiments also defeats any attempt to design a single general-purpose test set applicable to each.

Conversely, integration of the many experiments and support equipment into a single subsystem requires that a test set capability be provided for this level of test. Integration of the many individual instrument sets into a single subsystem test set is also economically unfeasible because of the considerable redundancy and surplus equipment that would exist. Therefore, the alternative is to design a set uniquely adapted to the subsystem test task by judicious selection of various instrument test-set capabilities.

The preferred configuration selected consists of the ten test sets described in paragraph 2.6.2. Nine of these sets are instrument- or major subassembly-oriented and are in the classification of special-purpose test sets. The tenth set follows a more general-purpose test set concept, but is designed primarily for assembled subsystem testing. This is a modification of alternative 2 wherein and end-to-end subsystem capability is provided, but the more detailed instrument-to-instrument and instrument-to-data-processing equipment interface simulation is eliminated.

The selected approach offers far more flexibility and overall economy than would be achieved by the application of either alternative 1 or alternative 2 exclusively.

2.7 Telemetry

The telemetry subsystem test set is designed to check out the Surface Laboratory telemetry subsystem. The major equipment elements requiring test are a Surface Laboratory data encoder, a backup data encoder, transducer power supply, signal conditioner, and the battery measurement multiplexer.

2.7.1 Requirements and Constraints

The general requirements and constraints for subsystem OSE are described in paragraph 2.1.1. Specific requirements, the parameters to be tested, and the constraints imposed by the design of the flight telemetry equipment, are discussed here.

Subsystem Test Requirements - The OSE must perform tests to evaluate the following performance parameters:

1) Data encoder conversion accuracy, channel crosstalk, common mode rejection, and sampling sequence - These are end-to-end tests of analog and digital channels, wherein accurately known, unique inputs, with and without superimposed common mode voltage are applied to each channel in appropriate combinations and sequences. The binary coded output signal is compared to the known inputs for each channel
2) Data encoder output formats, and response to commands - Appropriate discrete signals are applied to the encoder under test, to command it to each of its operating modes. In each mode the output is checked for proper waveform, bit rate, synchronization and identification codes, and frame length. Known, identifiable data inputs are provided when the encoder is in the data storage mode. The validity of data acquired, stored, and recovered is checked by subsequently commanding it to each transmitting mode
3) Conversion accuracy, sampling sequence, channel crosstalk, format, and common mode rejection tests of the battery measurement multiplexer are analogous to those above, except that the output signal is pulse duration modulated (PDM) rather than pulse code modulated (PCM)
4) Transducer power supply regulation and accuracy is checked by accurately measuring its output voltage, while the input voltage and load are varied
5) Marginal performance tests - Any or all of the above parameters are checked to determine limits of proper operation, and the type and degree of performance degradation while the supply voltage, command signals, and loads are varied beyond the normal interface tolerances.

Functional Requirements - To perform the above types of tests in the context of the general requirements, the following functions are required:

1) Simulate analog, digital, and discrete data input signals to the data encoder channels singly and in various combinations. The signal amplitudes and waveforms are accurately controlled and may be superimposed on controlled common mode voltages
2) Provide inputs to the battery measurement multiplexer, simulating the input signals and common mode voltages
3) Provide power to the telemetry subsystem, simulating the power normally supplied by the SLS power subsystem
4) Provide discrete command signals for control of the data encoder operating modes and bit rates
5) Provide for monitoring and analyzing the binary coded output of each data encoder so that the formats, conversion accuracy, multiplexing sequences, and other significant performance parameters can be evaluated. The output signal is in one of the following forms, depending on the transmitting data mode:
   a) Serial binary coded split-phase at 3584 bps
   b) Serial binary coded nonreturn to zero (NRZ) at 448, 224 or 112 bps, with pseudonoise code (PN) mod 2 added
   c) Parallel, binary coded 5-bit words at one word each 2.5 sec.
6) Supply nominal 28 vdc power to the battery measurement multiplexer and monitor the PDM output signal to evaluate the format, accuracy, sampling sequence, common mode rejection and channel crosstalk
7) Provide for comparison of data recovered from storage, with previously simulated data inputs to the Surface Laboratory data encoder operating in its storage mode
8) Vary the power voltage and interface control and sync parameters beyond the normal interface tolerances for marginal performance tests
9) Simulate analog data signal inputs to the signal conditioners (passive voltage dividers) at appropriate source impedances. Measure the input-to-output voltage ration of each channel
10) Provide automatic sequencing and evaluation of extensive repetitious test routines.

2.7.2 Preferred Preliminary Design

The preferred design is almost completely automated. It uses the subsystem, OSE computer system, intimately interfacing with the telemetry subsystem test set, as the complete telemetry subsystem OSE. Software test programs, stored in the computer, control the test sequence, the generation of stimuli, and contain criteria for evaluation of the responses to each test step or sequence.

Functional Description - Figure 2-29 functionally identifies the configuration of the test set. A command decoder and a digital-to-analog channel controller are standard equipment to provide the subsystem OSE computer system interface for control of the test sequence and stimuli. The power supply is programable over a range beyond the normal SLS power voltage, for marginal tests of the telemetry subsystem. Power control relays determine the components in the flight equipment to which power is supplied. The mode control unit generates command signals, simulating the sequencer-timer signals, for control of the data encoders to any normal mode of operation. The amplitude and duration of the signals are controllable, for marginal response tests. A set of resistors provides controlled, variable loads to the transducer power supply.

Three isolated outputs of digital-to-analog converters are independently routed to telemetry analog channels or groups of channels and/or combined to superimpose controlled common mode voltage by the signal switching matrix. Digital data inputs are simulated with shift registers whose contents are loaded by data from the subsystem OSE computer system and serially shifted out by either the SDS simulator or the telemetry clock, as appropriate, to the telemetry operating mode and the data source simulation. Discrete data inputs are simulated with switches whose states are set and altered by computer data.

The serial PCM and PDM outputs are selected and appropriately routed, either directly or through the PN/PSK demodulator, to the telemetry preprocessor (part of subsystem OSE computer system). The 5-bit parallel data output is buffered and conditioned for entry to the preprocessor. Signals from direct access connections to the telemetry subsystem and from test points within the test set are sampled, converted, and buffered for computer system access using conventional computer input/output hardware. The internal test points include those required to isolate problems between the OSE and telemetry subsystem.

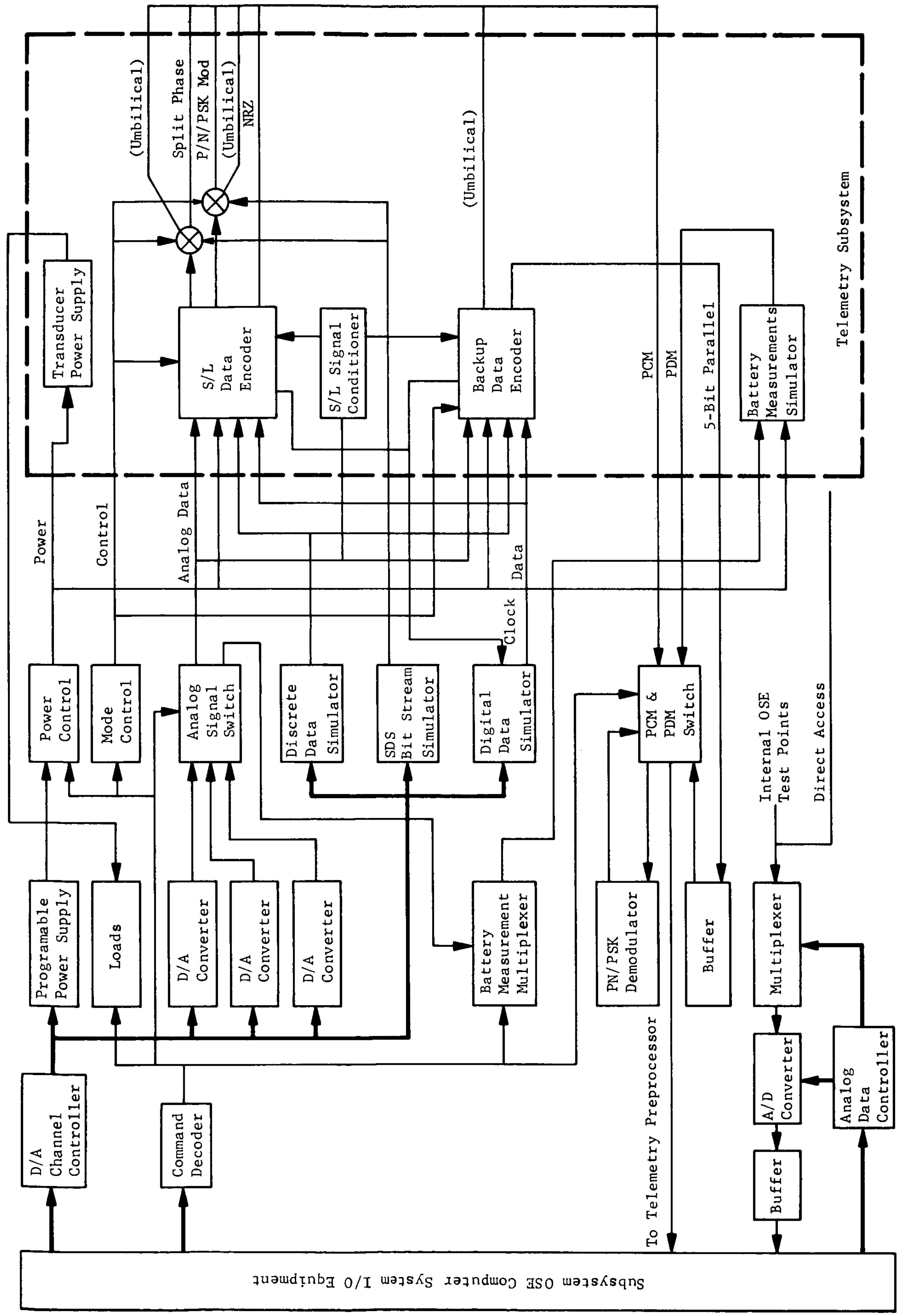


Fig. 2-29 Telemetry Subsystem Test Set

A cathode ray oscilloscope and multimeter are built into the test set to permite further trouble analysis and for visual monitoring of the PCM or PDM wave-train by the operator during tests.

Among the direct access test points monitored are the power applied to each serialization-controlled component under test. The computer system is programed to respond to these signals to accumulate the total operating time for each unit, associated with its serial number.

Physical Characteristics - The telemetry subsystem test set is housed in two standard OSE racks (Fig. 2-30). Input power is nominal 120 v, 60 Hz, single phase, at approximately 1000 w. The operator's console is the standard test station console described in paragraph 2.2.2 as a part of the subsystem OSE computer system.

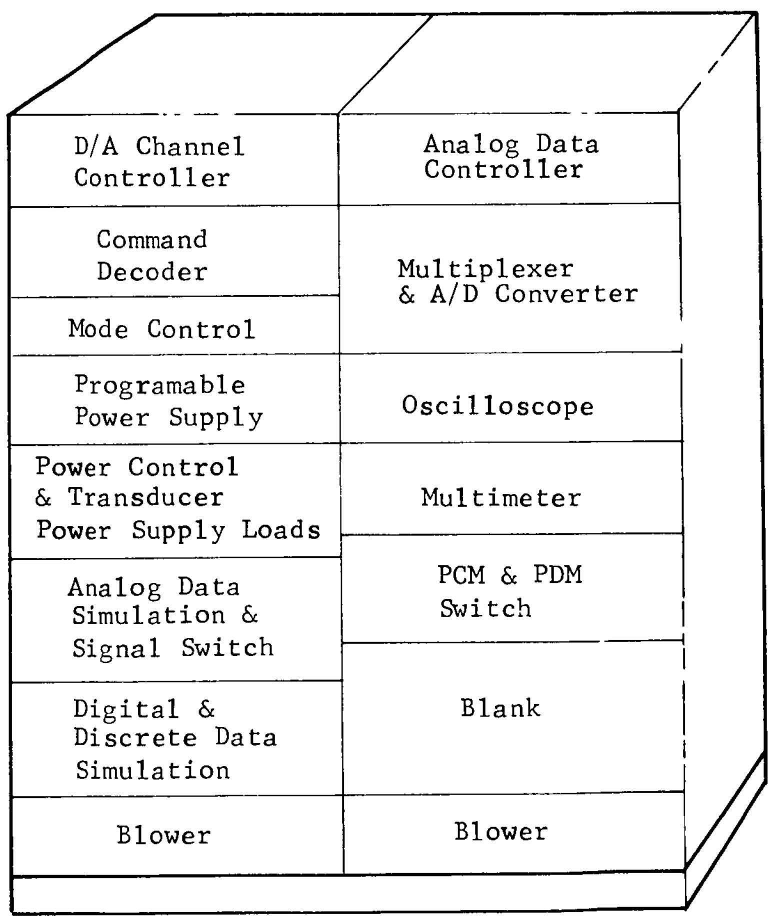


Fig. 2-30 Telemetry Subsystem Test Set

Interfaces - The test set interfaces with the flight telemetry subsystem and the subsystem OSE computer system.

Physical interface with the telemetry subsystem is with electrical cable connectors only. The functional interface summary is approximated as follows:

1) Power input - 4 lines
2) Signal inputs - 150 pairs
3) Signal outputs - 20 lines.

The functional interface with the subsystem OSE computer system is with digital signals, with the single exception of the PDM pulse train output to the telemetry preprocessor. All test control is by digitally coded commands and data from the central processor. The data acquisition interface consists of PCM and PDM wavetrains, and the buffered output of the D/A converter.

2.7.3 Subsystem Analyses

The preferred design is automatic to the maximum pratical extent, for both test control and data acquisition. A thorough subsystem test is estimated to require generation and evaluation of as many as 15,000 data points. An efficient technician would take at least 15 working days to perform the test manually, and would be prone to make errors due to the routine, repetitious nature of most of the test sequences. Automatic test, to the same degree of thoroughness, will require less than a single working day, including setup time. While it is difficult to assess the cost of operator mistakes, the saving in test time alone will more than offset the additional cost of automating.

Manual control is through the subsystem OSE computer system, and consists primarily of calling up the desired test program, starting, stopping, or interrupting the test. The operator can also alter the test sequence and parameters, but this is also done through the computer to ensure that any deviations from the established test program are recorded.

2.8 Communications OSE

The communications portion of the Surface Laboratory System consists of:

1) A direct radio (S-band) communication subsystem

2) A relay radio (UHF) communications subsystem.

In their flight configurations, the subsystems are physically and functionally independent. Necessarily, an S-band communications test set and a UHF communications test set have been designed and are described.

2.8.1 S-Band Communications OSE

2.8.1.1 Requirements and Constraints

General - The S-band communications OSE is designed to test and evaluate the performance of the Surface Laboratory direct radio communications subsystem. Using the subsystem OSE computer system, the OSE test set, described herein, exercises the subsystem in all its standard and backup operating modes to ensure the performance of its components within design limits.

Program requirements and constraints, in addition to those in paragraph 1.0, which are applicable to the SLS S-band communications OSE are given in the following paragraphs.

Design Constraints - Major constraints pertinent to the overall OSE design include:

1) The OSE must be designed for computer-controlled operation to the extent possible

2) OSE software and hardware must, to the extent practicable, be applicable to or compatible with STC testing

3) OSE design must, where possible, use MDE hardware

4) The test set must retain the capability of manual operation, using peripheral equipment, for nonstandard, lower level testing

Flight Equipment Applicability - The S-band communications OSE is designed to test and evaluate the S-band communications equipment at the independent replaceable assembly level and the integrated subsystem level, providing fault isolation respectively to the next lower assembly. The major flight equipment to be tested include:

1) M'ary modulator

2) Modulator exciter (2)

3) Transmitter selector

4) Power amplifier - TWTA (2)

5) Receiver selector

6) Receiver (2)
7) Command detector (2)
8) Diplexer (2)
9) Antenna switches (2)
10) Antenna pointer/controller
11) High-gain antenna
12) Low-gain antenna.

Functional Requirements - The functional requirements include:

Subsystem - For end-to-end subsystem testing, the test set includes:

1) Simulated subsystem telemetry inputs, both high-rate PN/PSK data and emergency low-data-rate parallel digital
2) S-band receiver and antenna for receipt of the subsystem RF output
3) Demodulators and detectors for recovery of base-band telemetry data
4) Spectrum analysis and measurement equipment for evaluation of subsystem RF predetection characteristics
5) Command encoder and PN modulator for generation of simulated commands
6) S-band test transmitter for transmission of command data
7) Digital comparators for signal output verification
8) Simulated sequencer-timer (S/T) command signals
9) Telemetry voltage calibration and measurement capabilities
10) Programable input power and power monitoring
11) Signal conditioning and buffering for translation of test results to computer language for control and evaluation.

Transponder/Power Amplifier - In testing for the S-band transponder functions the OSE:

1) Simulates the RF portion of a DSIF station
2) Monitors the S-band subsystem inputs and outputs before and after the power amplifier
3) Provides both a hardline and radiated RF link
4) Provides demodulation of the down-link RF signals. The OSE provides an intermediate frequency for use of MDE equipment for signal processing
5) Provides a simulated second Planetary Vehicle frequency
6) Provides a variable frequency and power level source for threshold and bandwidth determination
7) Provides the proper loading for test at various power output levels.

Command Detection - For testing the SLS command detection system the OSE provides:

1) Command encoding and modulating, to simulate base-band signal inputs
2) Demodulation and detection of signals for OSE command verification independent of test conditions
3) Error detection to evaluate the processed signal.

Base-Band Modulators - The OSE includes equipment and signal paths for test and evaluation of the data links before and through the S-band stages. The OSE:

1) Provides an unmodulated and PN-modulated PSK signal source to the modulator-exciters
2) Evaluates M'ary modulator performance both at base-band and RF by demodulating, using the subsystem OSE computer system, and comparing with the simulated signals.

Antennas and Antenna Control - Before and during mating with the communications electronics, the OSE:

1) Provides simulated control signals for evaluation of antenna positioning responses
2) Provides a radiated RF signal for antenna reception.

OSE Self-Test - The S-band communications test set includes the equipment and ability to complete all test loops internally for evaluation of OSE performance.

Design Requirements - The S-band communications OSE is designed to verify that the flight equipment is operating within design specified limits. The test set performs the specific tests described below to the accuracy given.

Power Output - The transmitter output power level to the high- and low-gain antennas is measured with an accuracy of ± 1.0 db.

Output Frequency - The output frequencies at the S-band transmitter are measured with an accuracy of 1 part in 10^7.

Deviation Sensitivity - The S-band transmitter deviation sensitivity is measured with an accuracy of $\pm 5\%$.

Modulation Characteristics - Modulation linearity and frequency response of the S-band transmitter are measured with an accuracy of $\pm 3\%$.

RF Spurious Outputs - The test set measures harmonically and nonharmonically related spurious signals to at least the fifth harmonic of the output frequency over a dynamic range of 60 db below transponder output power.

Incidental FM and Phase Jitter - The test set provides the ability to measure incidental FM and phase jitter of 36 db ($\pm 2°$) below the transmitter operational deviation of ± 2 rad.

Transmitter Selector Switching - The OSE provides the ability to exercise all operational and backup modes of the transmitter selector.

Receiver Demodulation Characteristics - Linearity and frequency response of the S-band receiver command channel are measured with an accuracy of $\pm 3\%$.

Rejection of Second Planetary Vehicle RF Signals - The ability of the S-band receivers to reject S-band signals at the frequency of a second planetary vehicle is checked using a variable-frequency S-band signal generator with a minimum output level range of -100 dbm to 0 dbm.

In-Lock Signal - The signal strength at which the receiver locks up is determined with an accuracy of ± 1 db. The up-link frequency is measured with an accuracy of ± 1 part in 10^7.

Receiver Selector Switching - The receiver selector switching is exercised in all of its operational modes.

Power Consumption - The dc input power to the S-band assembly must be measured with an accuracy of $\pm 2\%$.

Bit Error Rates - The overall bit error rate of the modulator exciter and TWTA; MFS modulator, modulator-exciter, and TWTA; and receiver and command detector is measured to an accuracy of 1 part in 10^5.

Command Detector Output Waveform - The detected command signal amplitude is measured with an accuracy of $\pm 3\%$. Rise times are resolvable within ± 1 ms.

Command Detector Acquisition Time - Worst-case command detector acquisition time is determined within an accuracy of ± 50 ms.

Telemetry Voltages - All flight equipment telemetry voltage responses are measured with an accuracy of $\pm 2\%$.

Voltage Standing Wave Ratio (VSWR) - Low- and high-gain antenna coupling VSWR is measured with an accuracy of $\pm 2\%$.

Antenna Control Response - The OSE will initiate and measure the response of the antenna point and control equipment to an accuracy of ± 1 deg.

2.8.1.2 Preferred Preliminary Design

The S-band communications OSE contains standard commercial and special test equipment for testing the SLS S-band subsystem. The OSE is configured so that stimulus and monitor equipment selection and signal routing are controlled primarily by the OSE subsystem computer system.

A simplified block diagram of the S-band test set is shown in Fig. 2-31. Major data paths are shown (solid lines); dashed lines represent control paths from the OSE computer system through the test set buffering. Operation of the test set, as shown in the diagram, is summarized as follows:

1) The up-link RF signal from the test transmitter is routed to any one of the S-band receivers via hardline as selected by coaxial relays
2) For radiated RF link tests, the test transmitter output is routed to a special test antenna through a power amplifier.
3) The test transmitter output level is programed by external command for sensitivity test of the receivers
4) The noise generator output level is programed by external command to provide discrete signal-to-noise ratios at the receiver inputs
5) The S-band signal generator output is connected so that an RF signal can be supplied to any one or more of the receiver inputs for test of the receiver selector
6) All RF coaxial relays are connected so that the unswitched side is terminated in a load matched to the line
7) Isolators and circulators (RF switching) are used to separate the RF signals and to isolate the test equipment and prime equipment
8) The down-link signal to be monitored by the OSE can be selected from any one of the flight antenna inputs or from the test antenna as commanded
9) An electronic switch and control is provided for protection of the power metering and test receiver input circuitry
10) Switching is provided for patching the spectrum analyzer and/or frequency counter with various RF paths
11) Test access is provided for convenient calibration of the attenuation in the RF paths
12) RF-closed-loop self-test is provided by the radio simulator (MDE), which simulates the flight transponder functions
13) Down-link modulation stimulus is remotely selectable from the test pattern generator
14) Commands are initiated or generated and PN modulated by command MDE
15) A controlled rate of frequency change of the test transmitter output is provided by the low-frequency function generator.

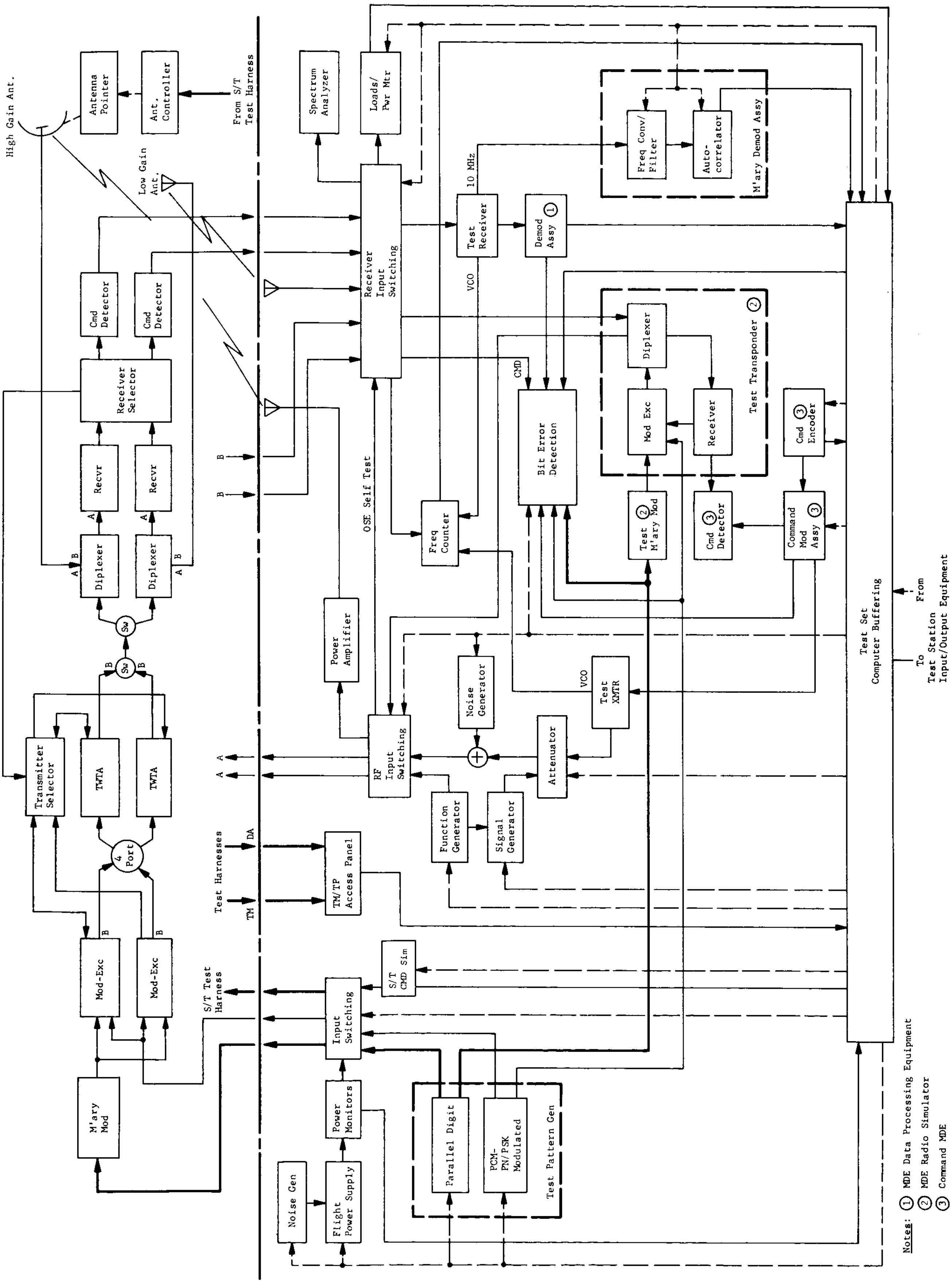


Fig. 2-31 S-Band Communications Test Set

16) Direct current to operate the flight equipment is supplied and controlled via the power control panel.
17) All the S-band subsystem monitor points (except RF), stimulus monitor, and response monitor points are routed to the static monitor panel, which is remotely controlled to select any monitor point and route the signal to the appropriate meter
18) The power meter and voltmeter are selected to provide analog outputs, which are routed to the computer buffering circuitry as required
19) The downlink demodulation processes are performed by Mission-Dependent Equipment (MDE). The test set simulates the DSIF interfaces
20) M'ary demodulation is performed (MDE) by a correlation, digital computation technique. A general-prupose computer performs the digital computation and controls the correlation and filtering.

Physical Characteristics - The complement of test equipment comprising the S-band communications OSE can be categorized as follows:

1) S-band communications test set
2) Flight component interface equipment
3) Ancilliary OSE components.

Test Set - A rack layout showing a preliminary configuration for the S-band test set is shown in Fig. 2-32. This segment of the OSE consists of five racks (two double, one single control unit) arranged to operate as an integrated checkout system with the ancilliary equipment and with the subsystem OSE computer system. The radio simulator, being of MDE design, is a rack-adapted portable unit within the test set.

Flight Component Interface Equipment - This class of test equipment (not shown) consists of:

1) Flight equipment buffer and interface connectors
2) Test harnesses
3) Breakout boxes, etc.

Ancilliary OSE Components - Equipment required to adapt the test set to various test configurations is not shown in Fig. 2-32 but includes:

1) OSE cabling
2) Test antennas
3) Attenuators, filters, etc
4) Miscellaneous RF hardware.

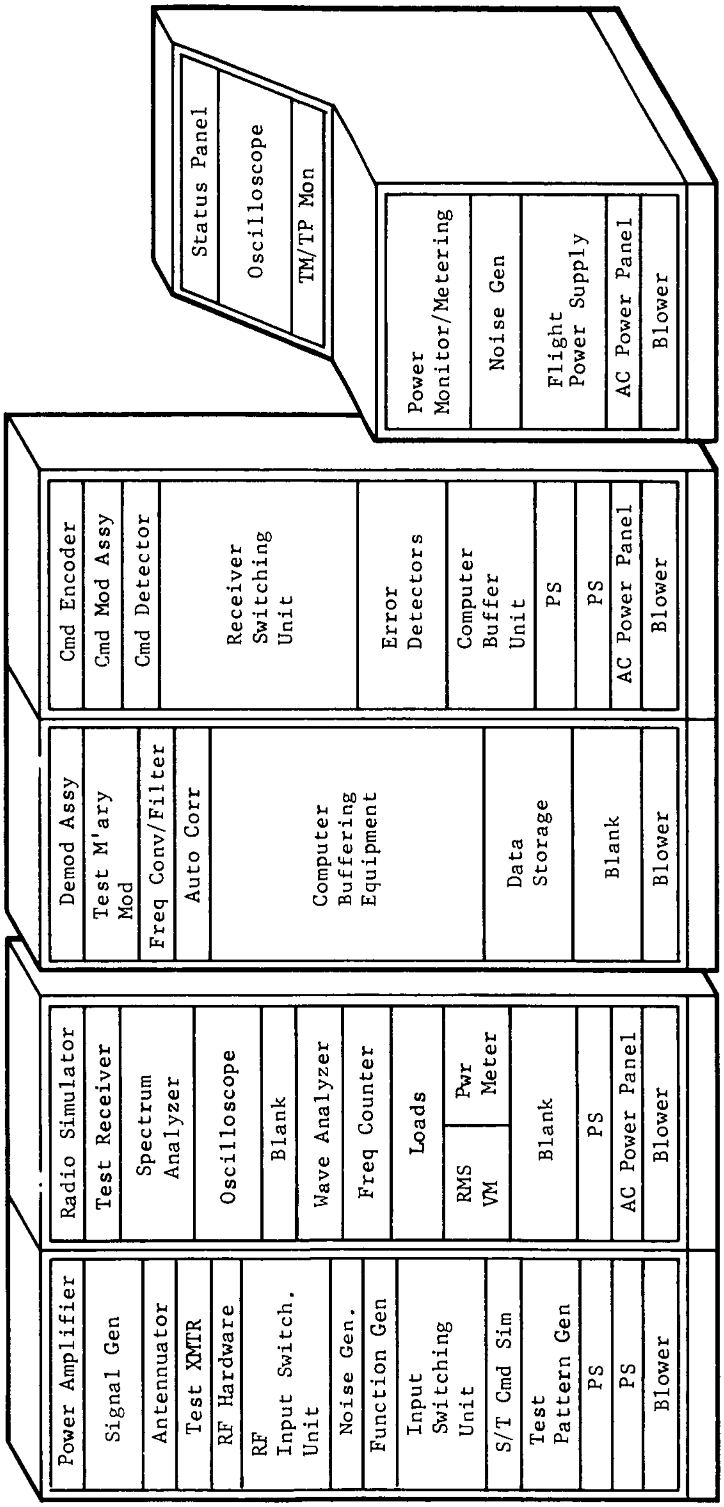


Fig. 2-32 Rack Layout of S-Band Communications Test Set

Description of Interface - Two areas of primary concern for the S-band communications test set are the OSE/flight component interface and the test set subsystem OSE computer system interface.

OSE/Flight Equipment Interface Definition - The S-band communications OSE interfaces with the flight equipment through both hardline connections and RF radiated links. A preliminary analysis indicates no apparent problem areas.

Radiated RF - The OSE equipments include test antennas for uplink and downlink communications with the flight equipment

Hardline Connections - Hardline interface signal paths include:

1) Input-output signal paths - in cases where the OSE interfaces directly with the flight connectors, buffer cables are used to minimize wear and damage possibilities
2) Telemetry voltages - a test TM harness adapts to the subsystem harness for pickup of telemetry voltages
3) Direct access monitors - the flight equipment includes test connectors for monitoring of test parameters. The OSE includes a test harness for hard wiring signals to monitoring equipment.

All signal paths, either hardline or RF, will terminate at the OSE in protective and isolating circuitry to avoid damage to flight equipment.

Test Set/Subsystem OSE Computer System - The S-band test set interfaces with the computer system at the test station input/output equipment. Circuitry in the test set provides the required signal conditioning for test control and data transmission.

2.8.1.3 Subsystem Analyses and Trade Studies

Certain preliminary design and trade studies have been undertaken to arrive at the preliminary design described. The following paragraphs describe these and future analyses to be performed before OSE final design.

Automated versus Manual Operation - In dealing with an RF system, basic disadvantages and obstacles are to be found when considering automated checkout modes. These include:

1) Complexity of equipment required including software
2) Reduced accuracy of test measurements
3) Inability to practically perform automated predetection measurements.

The advantages of automated checkout, however, are obvious. These include:

1) Reduction of test time
2) Integrity of data from test to test

3) Continuity of data for all levels of test through the use of common software and hardware

4) More efficient and economical data reduction.

A semiautomated configuration has been preliminarily designed; the total extent of computer control in the OSE will require further analysis.

Fault Isolation Techniques - In isolating faults in a replaceable assembly to the flight subsystem spares level, a tradeoff is required as to technique and signal availability. Test connectors are available on all flight components; however, reliability and accessibility is a consideration with excessive use of signal breakouts.

Final specification of required test points and fault isolating methods is required before final OSE and flight equipment design.

MDE USE - The use of MDE within the subsystem OSE is desirable from the criterion of establishing a history of operation of the MDE. In some areas (i.e., command and data demodulation) it is to be considered that the test requirements, in subsystem testing, are less stringent than those expected in mission operations. Thus, in areas where significant cost reductions could be achieved, the use of processing equipment, other than MDE, is being studied.

M'ary Demodulation - Preliminary study indicates that, during one M'ary data transmission, 8.7% of the computer capacity, assuming a σ-type capability, is used. A further study of the total subsystem OSE computer system use, thus its availability for M'ary demodulation processing, is being considered.

A possible approach, should final study results indicate an availability problem, will be to use a small general purpose computer for M'ary demodulation within the S-band test set.

2.8.2 UHF Communications OSE

2.8.2.1 Requirements and Constraints

General - The UHF communications test set is designed to test and evaluate the performance of the Surface Laboratory System relay communications subsystem. Using the subsystem OSE computer system for test control and data evaluation, the OSE is capable of exercising the subsystem through all of its standard and backup operating modes to ensure its performance within design limits.

The OSE tests the flight subsystem at the integrated subsystem and at the replaceable assembly level. Signal paths and diagnostic assistance are provided for fault isolation to the flight subsystem spares level.

As a design approach, the UHF communications test set described herein can, with minimum modification, test the Capsule Bus, Entry Science Package, and Surface Laboratory UHF communications subsystems.

Functional Requirements - For the performance test and evaluation of the communications subsystem and verification of OSE status, the test set provides:

1) A split-phase PCM input signal for simulation of the subsystem interface signal and conditions
2) A UHF receiver and demodulator for reception of the flight and OSE-generated relay link signals
3) A tone-modulated UHF signal for simulation of beacon transmission
4) Spectrum analysis equipment to evaluate the flight equipment and OSE-generated predetection signal outputs
5) Simulated commands for exercising the subsystem in all operating modes
6) Power supplies for subsystem independent operation
7) Signal paths and hardware for OSE configuring to accommodate all test modes
8) Signal routing and conditioning for conversion of subsystem test results to computer language
9) Signal paths and equipment for verification of OSE performance.

Design Requirements - The UHF communications test set is designed to verify that the flight subsystem is operating within design specified limits. Included in the OSE are commercial and special test equipment designed for the degree of accuracy necessary to establish confidence in the subsystem test results. Complemented by the subsystem OSE computer system, the test set satisfies design requirements of the flight subsystem as defined in the following paragraphs.

Integrated Subsystem - The test set checks the integrated subsystem for:

1) Signal spectrum - The subsystem RF output is analyzed as to spectral energy within the mark-space bandwidth with the OSE spectrum analyzer. Response to programed conditions of input voltage levels, rates and power supply noise is evaluated
2) Bit error detection - Subsystem bit errors are detected with an accuracy of 1 part in 10^5 over programed input conditions
3) Telemetry voltages - Telemetry outputs are calibrated, monitored and measured within an accuracy of $\pm 2\%$
4) Power consumption - Input power supplied the flight equipment is measured with an accuracy of $\pm 2\%$

5) Output power - The transmitter RF power to the antenna is measured to an accuracy of ± 1 db
6) Frequency output - The transmitter frequency is measured with an accuracy of ± 10 Hz
7) Spurious outputs - The OSE measures harmonically and nonharmonically related spurious signals over a dynamic range of 50 db or more.

Transmitter - The test set tests the transmitter for:

1) Frequency output and stability - Absolute frequency, stability, and spurious outputs
2) Voltage-controlled oscillator (VCO) - The static frequency of the transmitter VCO is measured to an accuracy of 1 part in 10^7
3) Modulation characteristics - Using a calibrated discriminator, the test set measures the modulation deviation with an accuracy of $\pm 5\%$ or better.

Beacon Receiver - The beacon receiver is checked for:

1) The OSE generates a selectable UHF frequency with a power level variable between -50 dbm and -140 dbm, with the ability to add a controlled level of noise. Threshold signal-to-noise of the receiver is measured to an accuracy of ± 1 db
2) The beacon receiver output signal amplitude is measured with an accuracy of $\pm 3\%$. Rise times are resolvable within ± 10 ms.

Transmitter/Antenna Mating Mismatch - The voltage standing wave ratio (VSWR) resulting from antenna/transmitter coupling is measured with an accuracy of $\pm 5\%$ or better.

Design Constraints - Major design constraints on the UHF communications OSE, in addition to those in paragraph 1.0, include:

1) The OSE must be designed for automated test control and data evaluation to the extent practicable
2) The design of the test set, so that it is readily adaptable to the Capsule Bus communications subsystem, and the Entry Science Package communications subsystem, must not compromise test results
3) OSE hardware and software design must, to the extent applicable, be adaptable to STC use
4) The OSE must retain the ability to be manually operated, using analog display and control peripheral equipment for nonstandard lower level testing.

2.8.2.2 Preferred Preliminary Design

Subsystem Definition - The subsystem definition is discussed below.

Flight Equipment Applicability - The Surface Laboratory System (SLS) relay communications subsystem comprises:

1) UHF transmitter
2) UHF beacon receiver
3) Antenna/coupler/diplexer assembly.

The transmitter accepts PCM data, split-phase encoded, from the SLS data encoder. The input signal controls a temperature-stabilized voltage-controlled crystal oscillator (VCXO), multiplier and amplifier stages follow the VCXO.

The UHF beacon receiver receives a radiated UHF signal from the Spacecraft-mounted Flight Capsule support equipment (SMFCSE) beacon transmitter; the carrier is amplitude modulated by an audio tone.

Two replaceable assemblies comprise the subsystem -- UHF transmitter beacon receiver and cabling, and antenna and coupler assembly. The test set is designed to test each assembly independently or as an integrated subsystem.

Functional Description - Figure 2-33 is a functional block diagram of the UHF communications test set. Only major signal paths and functions are shown. Dashed lines represent control functions; signal and data paths are shown as solid lines. Functionally, operation of the OSE may be described as follows:

Computer interfacing - The test set receives, decodes, and sequences the computer-generated test commands to within the test set. Through hardline discrete and analog voltage applications, the command sequencer initiates and level-controls the input stimulus generators, controls relay switching within the input and receiver switching units and the data select unit, and programs loading and terminating hardware.

All test and OSE data outputs are received within the test set computer buffer unit. The required signal conditioning (i.e., analog-to-digital conversion and scanning) are performed and the data transmitted to the computer system test station for processing and/or storage.

Stimulus generation and signal routing - The OSE, through the inclusion of signal generators, simulates the subsystem input signals. A test pattern generator provides the split-phase baseband signal to the flight or OSE modulators. A commercial signal generator, its output tone modulated, provides a variable frequency

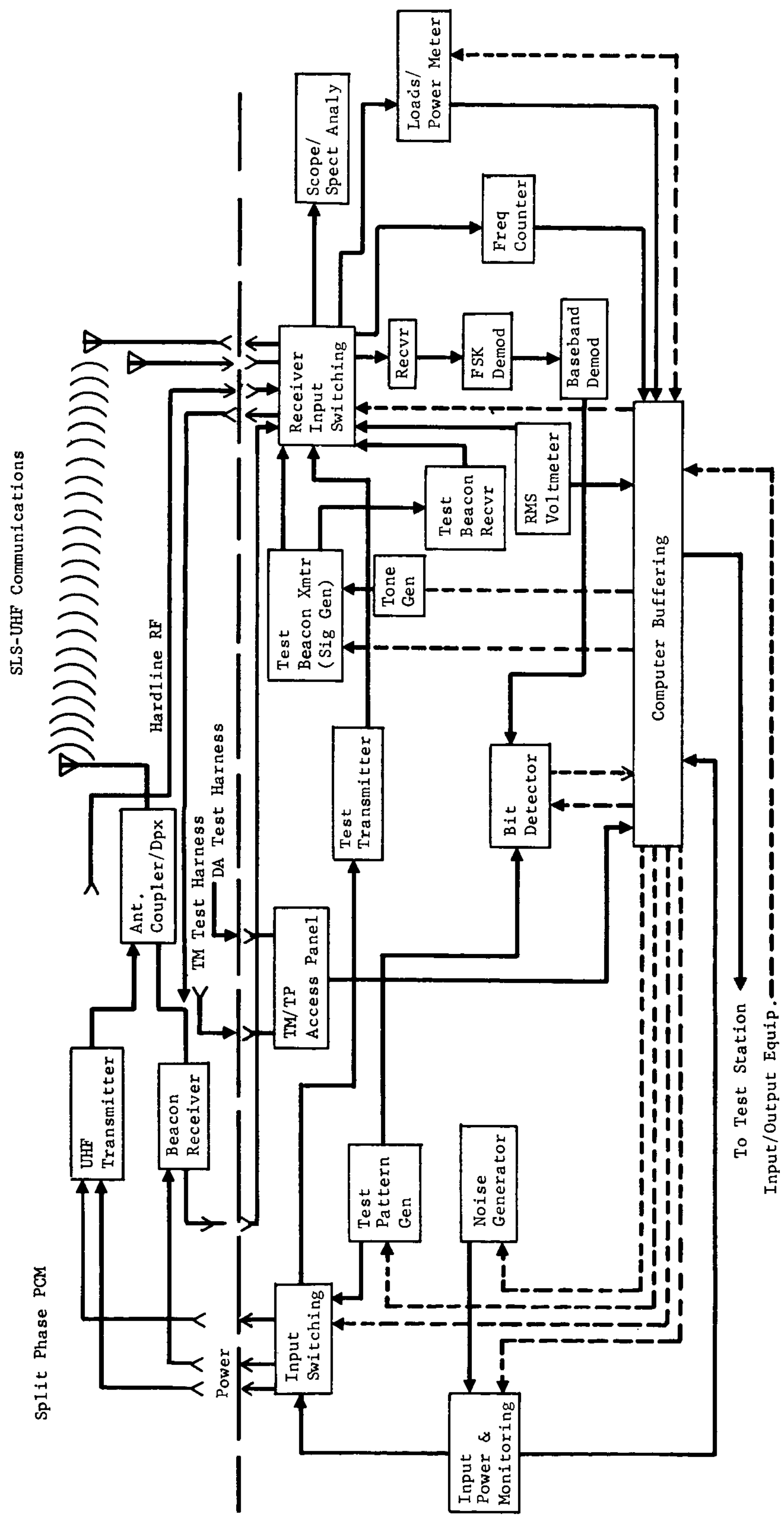


Fig. 2-33 Block Diagram UHF Communications Test Set

and power level input to the beacon receiver. Input power to the flight equipment is supplied and monitored. A programable noise generator provides for testing at discrete input signal-to-noise levels.

The OSE provides the requisite cabling and data paths to test all test configurations. Hardline and radiated signal paths interface with the flight equipment.

Receiving and processing - The OSE receives the flight equipment-generated RF signal either hardline or radiated. A receiver assembly frequency-converts and demodulates the received signal. The beacon receiver output is measured with an RMS voltmeter. Flight- or OSE-generated predetection RF signals are analyzed directly by the spectrum analyzer. Test set verification checks are provided for by the inclusion of a test modulator-exciter assembly and a test beacon receiver operating at the flight equipment frequency.

The OSE contains equipment (i.e., power meter, frequency counter, oscilloscope) for discrete measurements and waveform display of flight equipment and OSE parameters.

<u>Physical Characteristics</u> - The communications test set configuration includes:

1) Rack-mounted special and commercial test equipment
2) Flight equipment test harnesses for telemetry and test-point connector access
3) OSE ancillary equipment to adapt the test set to all test configurations.

Figure 2-34 shows a rack layout of the UHF communications test set.

<u>Description of Interfaces</u> - The UHF communications OSE is primarily concerned with two interface areas; subsystem OSE computer system, and flight equipment. Preliminary interface definitions are given below:

Computer/Test Set Interface - To adapt standard and special test equipment to automated testing, the test set contains the required command decoding and sequencing and output data signal-conditioning circuitry. This circuitry interfaces with the subsystem OSE computer system test station.

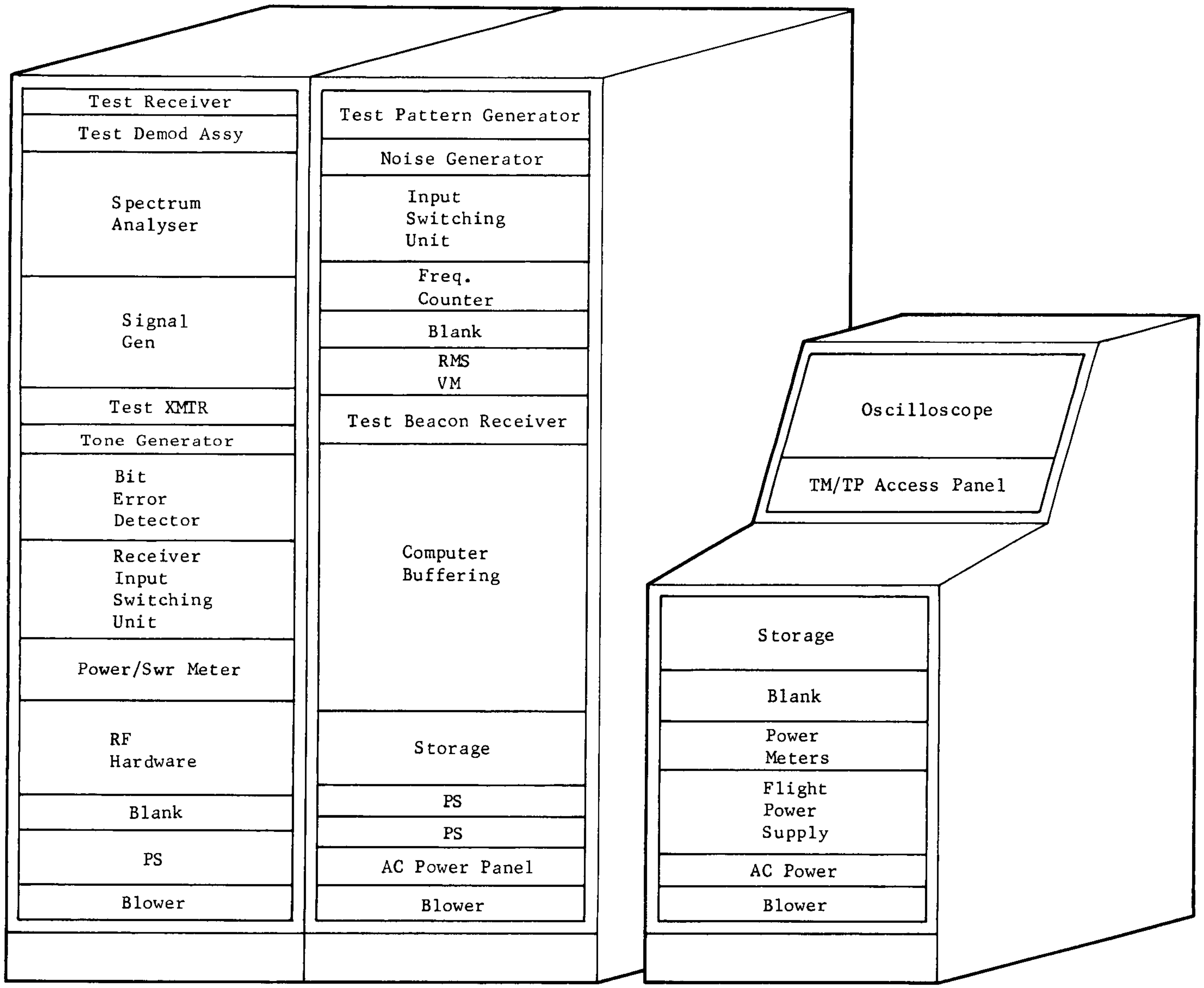


Fig. 2-34 Rack Layout UHF Communications Test Set

OSE/Flight Equipment Interface - The OSE interfaces with the flight equipment both with hardline and radiated RF signal paths. The OSE includes test antennas for transmission and reception. Other hardline connections to the flight equipment include:

1) Input power - Simulated bus voltages are supplied by the communications subsystem. Turn-on and steady-state voltage characteristics are preserved and monitored
2) Signal inputs - Simulated telemetry subsystem signals are supplied the transmitters by hardware connection
3) Monitor harnesses - Test harnesses, for TM and test connector monitoring are a part of the OSE
4) RF - The OSE provides the proper impedance matching cabling, attenuation and isolation for hardwire FR monitoring.

2.8.2.3 Subsystem Analyses and Trade Studies - Summaries and description of the preliminary analyses and trade studies and continuing efforts are described in the following paragraphs.

Automated versus Manual Operation - In adapting an RF test system for automated operation, basic disadvantages and obstacles must be considered:

1) Complexity and size of hardware required
2) Reduced accuracy of test measurements
3) Inability to practically perform automated predetection measurement and analysis.

The advantages of automated checkout, however, are obvious. They include:

1) Marked reduction of test time
2) Integrity of data from test to test
3) Continuity of data for all levels of test through the use of common hardware and software
4) More efficient and economical data reduction.

Fault-Isolation Techniques - The primary OSE tools in deriving a fault isolating technique are:

1) Input/output signal sources
2) Flight-designated telemetry voltages
3) Test-connector test signals.

Sources 1 and 2 are heavily constrained by overall system requirements; the use and specification of test connectors and signal availability are then the critical areas of OSE study.

Test connectors or direct-access points are available on all flight equipment. However, equipment accessibility and reliability limit their numbers, size, and use. A comprehensive study is required, and has been initiated, of the level of fault isolation to be reached absolutely by direct signal monitoring, and the level to be inferred from such available signals.

2.9 Power

The power and pyrotechnic subsystems test set checks out the Surface Laboratory power control equipment. Because the batteries are not electrically functional units until they have been formation-charged after the terminal sterilization cycle, no functional tests of actual flight batteries are performed at the subsystem level. The equipment required to charge the batteries and subsequently verify their functional integrity is part of the STC capability.

The power and pyrotechnic subsystems test set is designed to use common equipment for checkout of either subsystem, by integrating the test equipment required for both into one test set (paragraph 2.10). It uses the subsystem OSE computer system (paragraph 2.2.2) for test control and evaluation.

2.9.1 Requirements and Constraints

The general requirements and constraints for subsystem OSE are described in paragraph 2.1.1. Specific requirements and constraints resulting from the design of the flight power equipment and the parameters to be tested are discussed below.

2.9.1.1 Test Requirements

Performance parameters tested with the OSE are:

1) Load control and power transfer response to commands and faults
2) Isolation and grounding integrity
3) Parametric variation margins.

2.9.1.2 Functional Requirements

To perform these tests, in the context of the general subsystem OSE requirements, the test set must:

1) Simulate input power as provided by capsule bus adapter mounted voltage regulators, or SLS batteries
2) Simulate electrical loads
3) Provide discrete control signals in simulated mission sequences
4) Provide for varying power voltage, electrical loads, and discrete signal amplitude and duration beyond the normal flight subsystem interface tolerances
5) Provide automatic test sequencing, displays, and test data recording through compatible interface with the subsystem OSE computer system.

2.9.2 Preferred Preliminary Design

The preferred design incorporates automatic test control, using the subsystem OSE computer system for sequencing, data acquisition, and evaluation.

2.9.2.1 Functional Description

Figure 2-35 illustrates the functional configuration. Software test procedures stored in the computer control the test sequence, values of stimulus parameters, and electrical loads. Programable power supplies and a rechargeable battery provide isolated power sources, and simulation of flight battery characteristics. Power resistors and switching matrixes provide variable electrical loads and fault simulation. Power and load switching units connect the OSE to the appropriate input and output terminals for each test sequence. The command generator issues discrete control signals, variable in amplitude and duration, to the power subsystem.

A multiplexer and analog-to-digital converter provide the test data acquisition interface with the OSE computer. Direct access points, subsystem power interfaces, and telemetry outputs are accessed through appropriate power subsystem connectors. OSE test points include parameters required to isolate problems between OSE and equipment under test.

An oscilloscope and multimeter are built into the test set for further trouble analysis by the operator, and for visual monitoring.

2.9.2.2 Physical Characteristics

The test set is housed in two standard OSE racks (Fig. 2-36). Input power is nominal 115 v, 60 Hz, single-phase, at approximately 1200 w maximum. The operator's console is the standard test station console described in paragraph 2.2 as a part of the subsystem OSE computer system.

2.9.2.3 Interfaces

The test set interfaces with the flight power subsystem, the pyrotechnic subsystem, the subsystem OSE computer system, and the facility. Interfacing cable sets are provided to accommodate testing the power or pyrotechnic subsystem. Pyrotechnic subsystem test equipment is also located in one of the racks (Fig. 2-36) and has functional interfaces as described in paragraph 2.10.

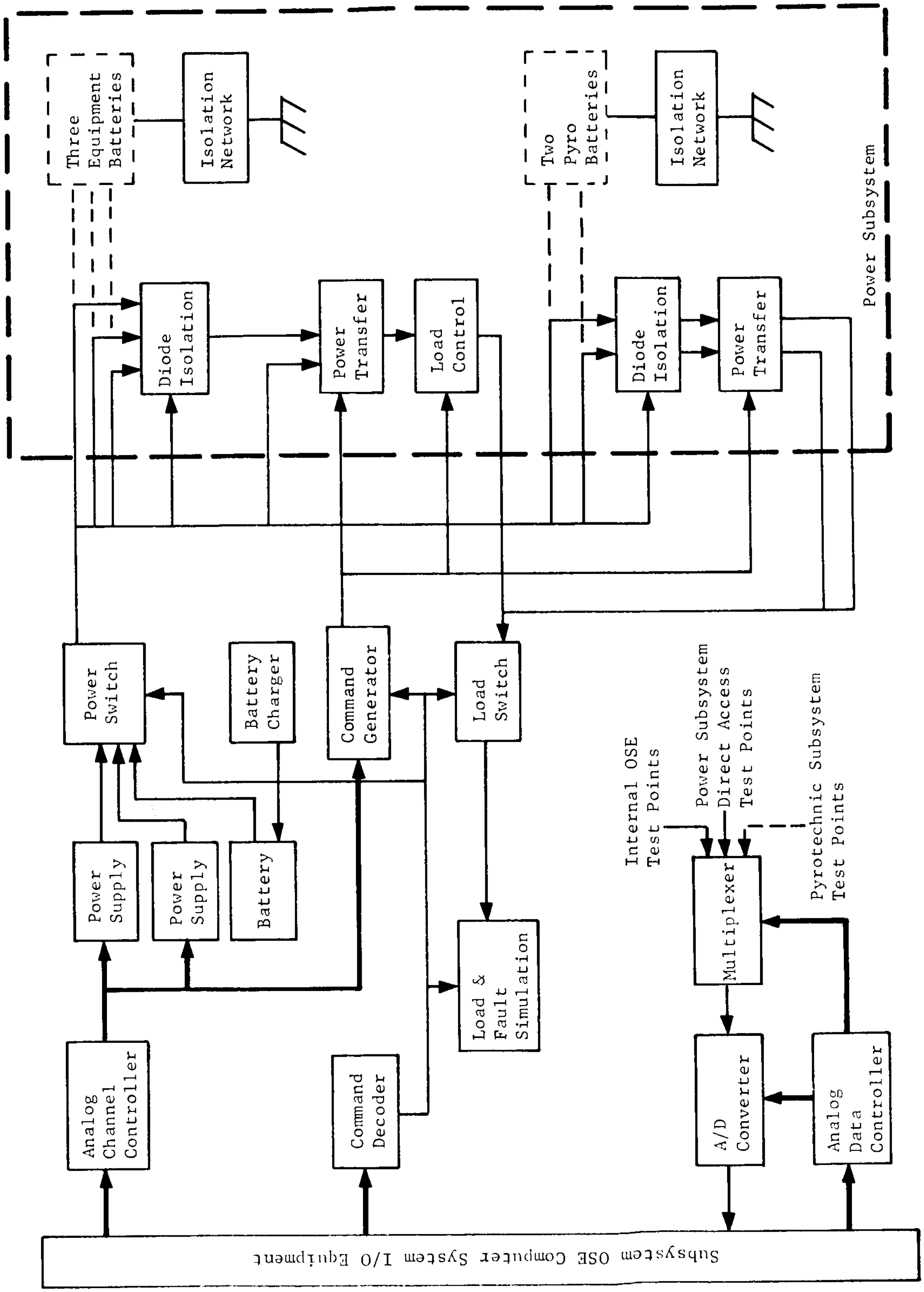


Fig. 2-35 Power Subsystem Test With Power and Pyrotechnic Subsystems Test Set

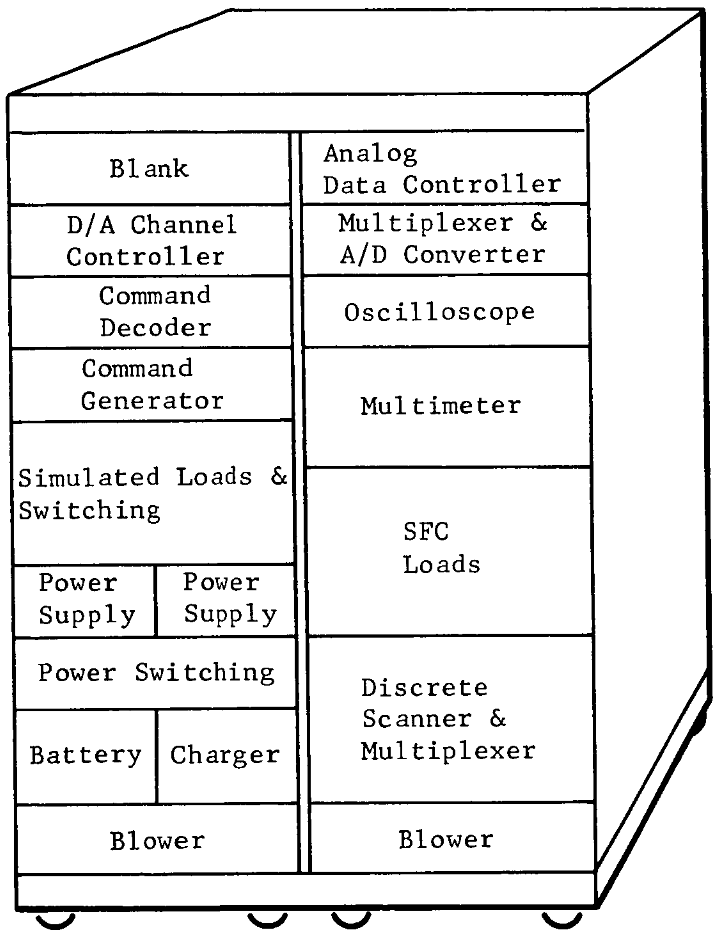


Fig. 2-36 Power and Pyrotechnic Subsystems Test Set

2.9.3 Subsystem Analyses

Significant design choices involved are manual versus automatic test control, and integrating power and pyrotechnic test sets versus separate equipment for each. Based on the availability of the subsystem OSE computer system, and the general requirement for subsystem OSE to be capable of "interfacing with a general-purpose computer system for test control and data acquisition," the cost-effective choice is to provide automatic test control and data acquisition for subsystem tests.

Most of the functional capability provided for power subsystem test is also required for pyrotechnic subsystem tests. Some additional equipment is required for pyrotechnic subsystem tests (paragraph 2.10). With the use of a set of interface adapter cables, sharing of the control, power, load simulation, and data acquisition capabilities is achieved.

2.10 Pyrotechnics

The power and pyrotechnic subsystem test set automatically tests the pyrotechnic control equipment as a subsystem, as well as the spares and replacement level packages. Squibs are tested separately.

2.10.1 Requirements and Constraints

There are two test configurations -- a pyrotechnic control assembly (consisting of 4 safe-arm relays and 8 squib firing circuits) and, a subsystem that includes 8 current-limiter assemblies and interconnecting cables. Performance parameters tested include "all-fire" and "no-fire" margins, redundancy validity, and parametric variation margins. To test these parameters in the context of the general requirements, the OSE provides power, discrete command signals, and electrical simulation of squib bridgewire circuits. It independently detects current above the "no-fire" and "all-fire" margins in each simulated bridgewire circuit.

2.10.2 Preferred Preliminary Design

The test set integrates the power and pyrotechnic test equipment making common use of the power supply, battery, control and data acquisition equipment.

2.10.2.1 Functional Description

Figure 2-37 illustrates the test set functions and its interfaces as used for pyrotechnic subsystem tests. For test of a complete subsystem, simulators are connected to the outputs in place of each squib. Each redundant path is exercised separately, which corresponds to a single failure in each path, while the scanner and multiplexer system monitors the threshold sensing signals from each simulator. For test of the replaceable control assembly package, a load is connected to the output of each squib firing circuit. The current and voltage at each load is measured as the equipment is exercised.

2.10.2.2 Physical Characteristics

The unique pyrotechnic test equipment added to the test set occupies approximately half a rack (Fig. 2-36). In addition, there are 48 small portable squib simulators, designed to be substituted for squibs, using identical connectors.

2.10.2.3 Interfaces

The test set interfaces with the pyrotechnic subsystem, the power subsystem, and the subsystem OSE computer system. Functional interfaces include the power and command signals, the electrical loads and squib simulation, and the control and data acquisition interface with the subsystem OSE computer system.

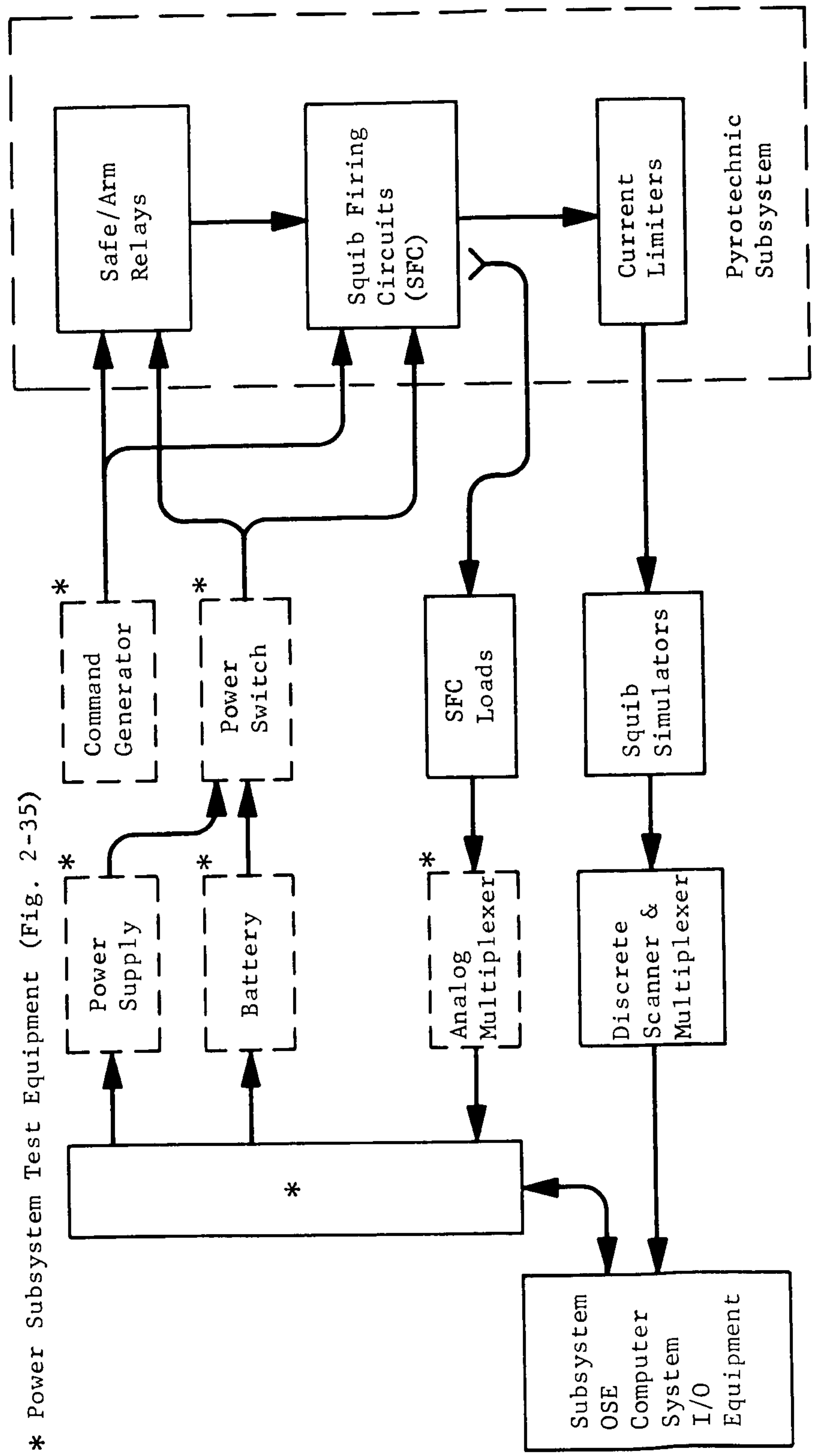


Fig. 2-37 Pyrotechnic Subsystem Test With Power and Pyrotechnic Subsystems Test Set

2.11 Cabling

The qualification and acceptance of interconnection cable harnesses for the flight systems requires equipment in support of these tests. These equipment requirements are satisfied by standard manufacturing tooling and no cabling subsystem OSE is required.

2.11.1 Requirements and Constraints

Qualification cable harness assemblies are subjected to continuity and insulation resistance checks, environmental exposures and connector engagement and pull tests. Cable assemblies are also installed in the Proof Test Model for qualification at the assembled flight system level.

Acceptance testing of cable assemblies for the mission flight systems consists of physical inspection, continuity and insulation resistance tests, ethylene oxide and heat sterilization exposures followed by retest.

2.11.2 Preferred Preliminary Design

The requirements above are satisfied by:

1) The qualification of cable assemblies is accomplished in facility-provided environmental test fixtures and chambers and verified with commercial test equipment (e.g., meggars, ohmmeters)
2) Acceptance testing is accomplished with standard manufacturing tooling (i.e., Hughes analyzers)
3) Final qualification and acceptance is accomplished in an assembled flight system and is demonstrated by proper operation of interconnected subsystems as monitored by the System Test Complex.

2.12 Spacecraft-Mounted Surface Laboratory Support Equipment

The Spacecraft-mounted Flight Capsule support equipment serves the Surface Laboratory, and is provided by the Capsule Bus System. The associated OSE is a part of the Capsule Bus System OSE.

3. SYSTEM TEST COMPLEX

The System Test Complex (STC) is a grouping of Operational Support Equipment (OSE) to provide a complete Surface Laboratory system test capability. The STC is also required to support Flight Capsule and Planetary Vehicle marriage tests and portions of the STC are required to support launch pad operations.

3.1 Requirements and Constraints

3.1.1 Functional and Design Requirements

Requirements and constraints of paragraph 1.0 and those specified in the following documents provide the basis for the design of the STCs.

1) SE003BB002-2A21 - Voyager Capsule Systems Constraints and Requirements Document, Revisión 2, dated 12 June 1967.
2) Report No. ED-22-6-52 - Trade Study, System Test Complex Configuration

3.2 Preferred Preliminary Design

3.2.1 System Definition

3.2.1.1 General

The System Test Complex implements a highly integrated system test philosophy. A Computer Data System (CDS) is used to effect command, control, monitoring and display functions. It is a cost-effective system providing a capability for computer sharing between Flight Capsule systems. It simplifies the logistics problems by minimizing the quantities of hardware that must be moved from test area to test area.

Figures 3-1 and 3-2 are functional block diagrams of the Surface Laboratory and Flight Capsule STCs. The STC is divided into two separate hardware groupings. A control center grouping, which remains fixed at a given contractor facility and at Kennedy Space Center (KSC), and a Capsule-vicinity grouping, which moves with the flight system test article from test area to test area. Figures 3-3 and 3-4 are pictorial representations of control center and Capsule-vicinity equipment, respectively.

Control Center Equipment - Control center equipment is divided into three classes of functional hardware, the control and display consoles for accomplishing the man-machine interfacing, the computer data system, and ancillary equipment.

Test Conductor's Console - A test conductor's console is provided, from which all Surface Laboratory test activities in the STC are initiated and directed.

Subsystem Display Consoles - These are provided for subsystem-oriented test personnel. This permits simultaneous real-time display of different data values oriented to Surface Laboratory subsystems.

Test Director's Console - This console for Flight Capsule STCs provides for overall test coordination of Capsule Bus, Surface Laboratory, and Entry Science Package test activities.

Computer Data System - The system is used for simultaneous testing of up to two Flight Capsules by modular buildup of peripheral equipment such as preprocessors, memory banks, input/output buffers, and magnetic tape transports.

The computer data system directs automatic and manual tests, as initiated by the test conductor, by issuing commands provided for in stored programs. The data acquired from the Surface Laboratory, OSE, and facility as a result of, or pertinent to, the test are recorded as raw data on magnetic tape and fed into the computer processing equipment for real-time analysis. Real-time multiple hard-copy printouts and permanent logs are made of the test data.

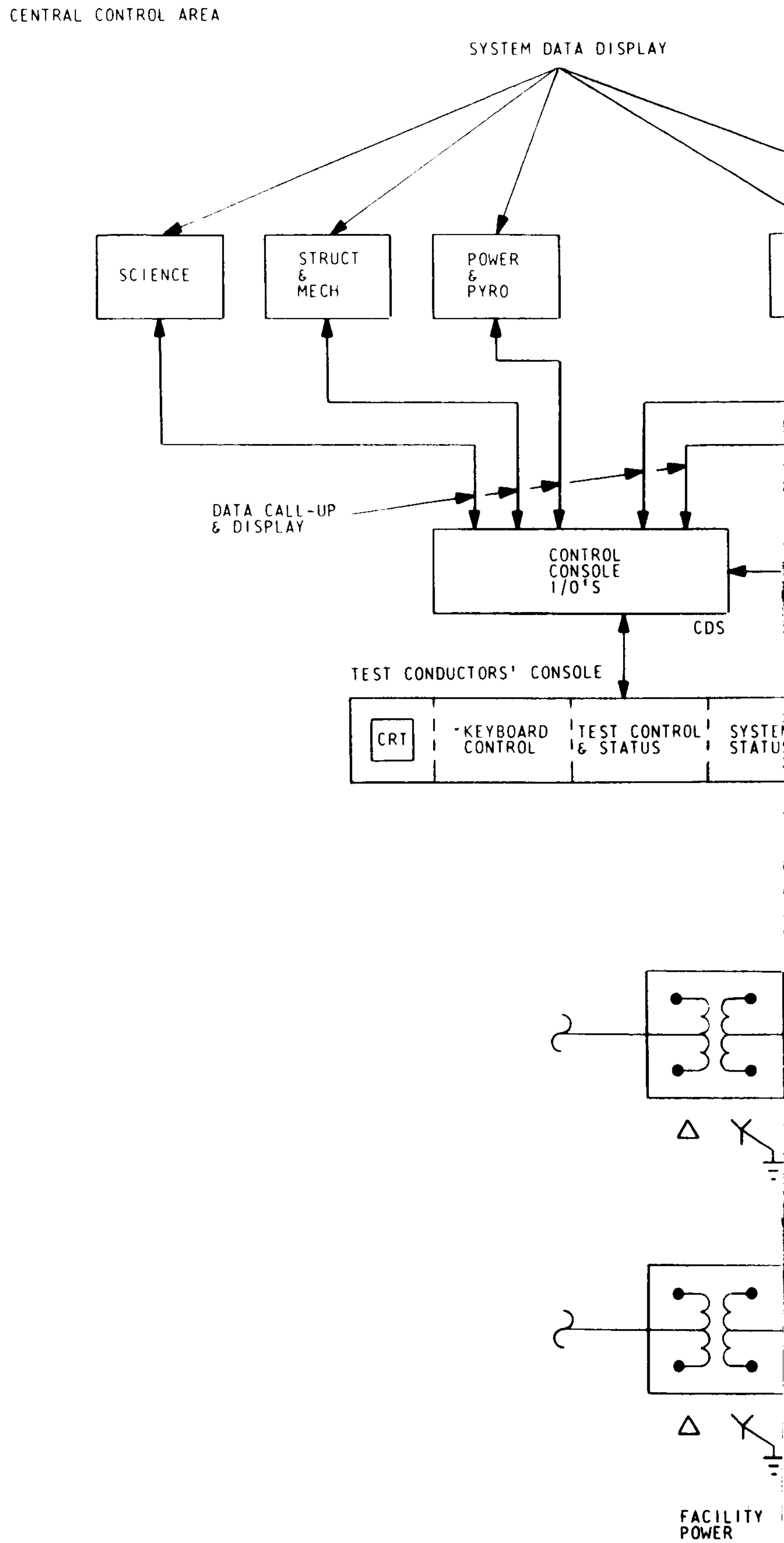
Prediction techniques can be used to determine impending conditions based on previous history of variation of test parameters. The history data are in the computer memory available for recall to the display and plotting devices. Real-time call-up display capability is available for parameters available at the computer input interfaces.

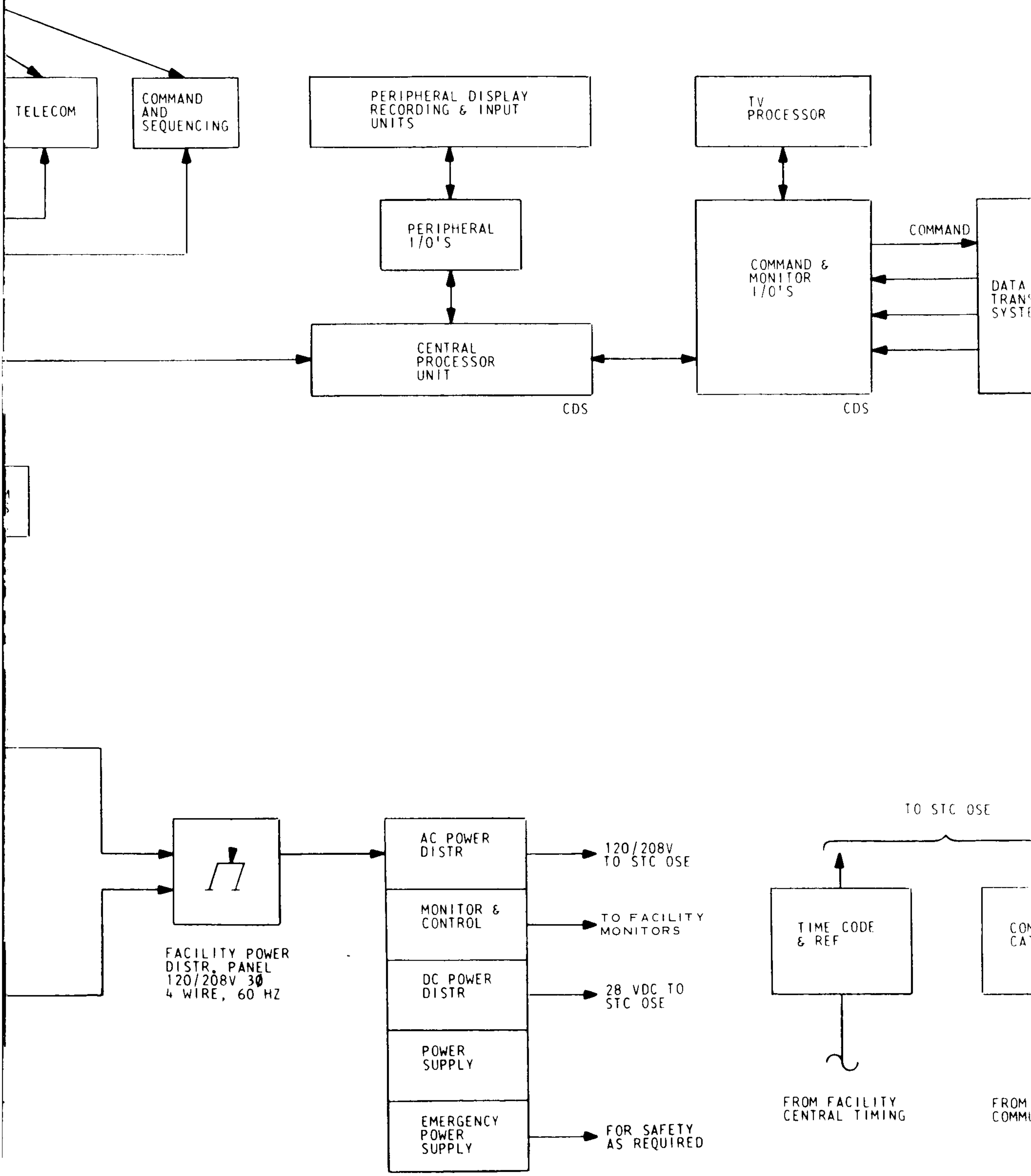
The computer data system and the subsystem OSE computer system (paragraph 2.2) use compatible processors and peripheral equipment.

Control Center Ancillary Equipment - This includes power supply and power distribution, voice communication, STC timing and time distribution and closed-circuit TV equipment. The ancillary equipment is designed with consideration given to its use at different contractor test facilities and at KSC. Quantities of this equipment vary from facility to facility.

STC Surface Laboratory-Vicinity Equipment - This equipment is divided into three functional classes -- computer command and data acquisition, unique subsystem OSE, and ancillary or support equipment.

The computer command and data acquisition general-purpose equipment provides the ability to command Surface Laboratory, OSE, and facility control interfaces and to acquire Surface Laboratory, OSE, and facility parameter data for transmission to the control center and computer. It includes modular designs common to subsystem OSE.


CENTRAL CONTROL AREA
SYSTEM DATA DISPLAY
SCIENCE
STRUCT & MECH
POWER & PYRO
DATA CALL-UP & DISPLAY
CONTROL CONSOLE I/O'S
CDS
TEST CONDUCTORS' CONSOLE
CRT
KEYBOARD CONTROL
TEST CONTROL & STATUS
FACILITY POWER


TELECOM
COMMAND AND SEQUENCING
PERIPHERAL DISPLAY RECORDING & INPUT UNITS
TV PROCESSOR
PERIPHERAL I/O'S
COMMAND
COMMAND & MONITOR I/O'S
DATA TRAN
SYSTE
CENTRAL PROCESSOR UNIT
CDS
CDS
TO STC OSE
AC POWER DISTR
120/208V TO STC OSE
MONITOR & CONTROL
TO FACILITY MONITORS
FACILITY POWER DISTR. PANEL 120/208V 3Ø 4 WIRE, 60 HZ
DC POWER DISTR
28 VDC TO STC OSE
POWER SUPPLY
EMERGENCY POWER SUPPLY
FOR SAFETY AS REQUIRED
TIME CODE & REF
FROM FACILITY CENTRAL TIMING
CON
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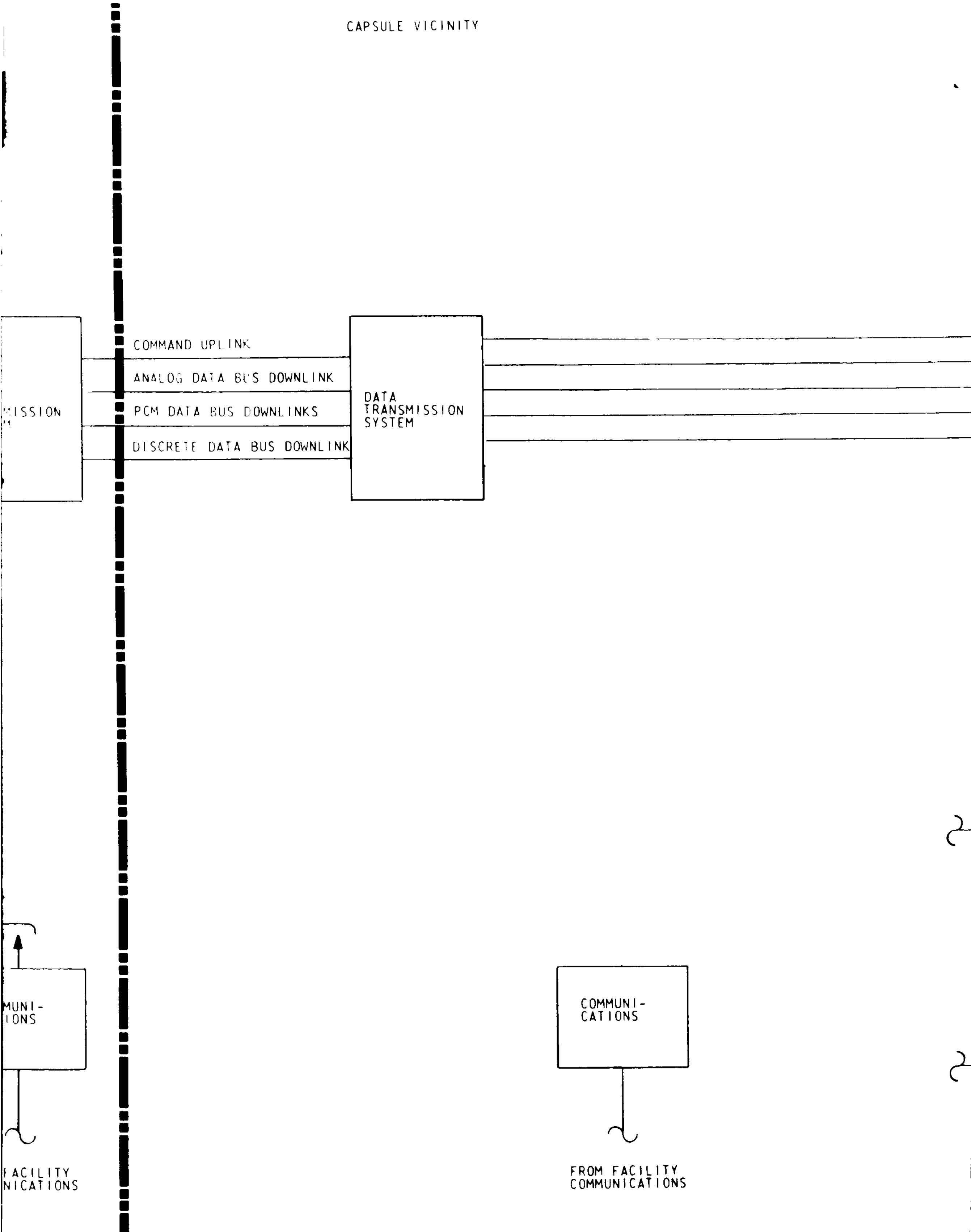
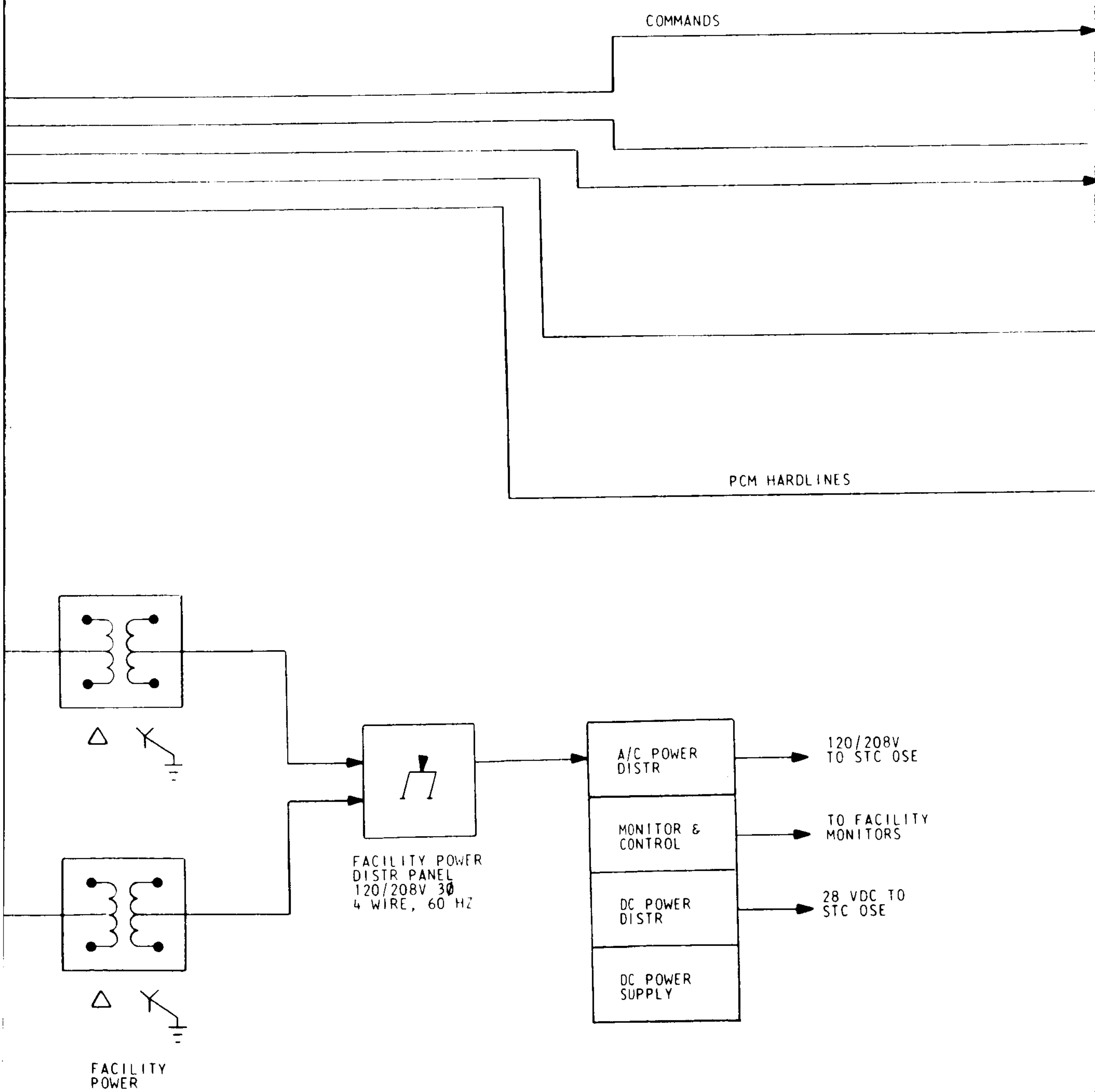


Fig. 3-1 Surface Laboratory STC Configuration


COMMANDS
PCM HARDLINES
FACILITY POWER
FACILITY POWER DISTR PANEL 120/208V 3Ø 4 WIRE, 60 HZ
A/C POWER DISTR
MONITOR & CONTROL
DC POWER DISTR
DC POWER SUPPLY
120/208V TO STC OSE
TO FACILITY MONITORS
28 VDC TO STC OSE

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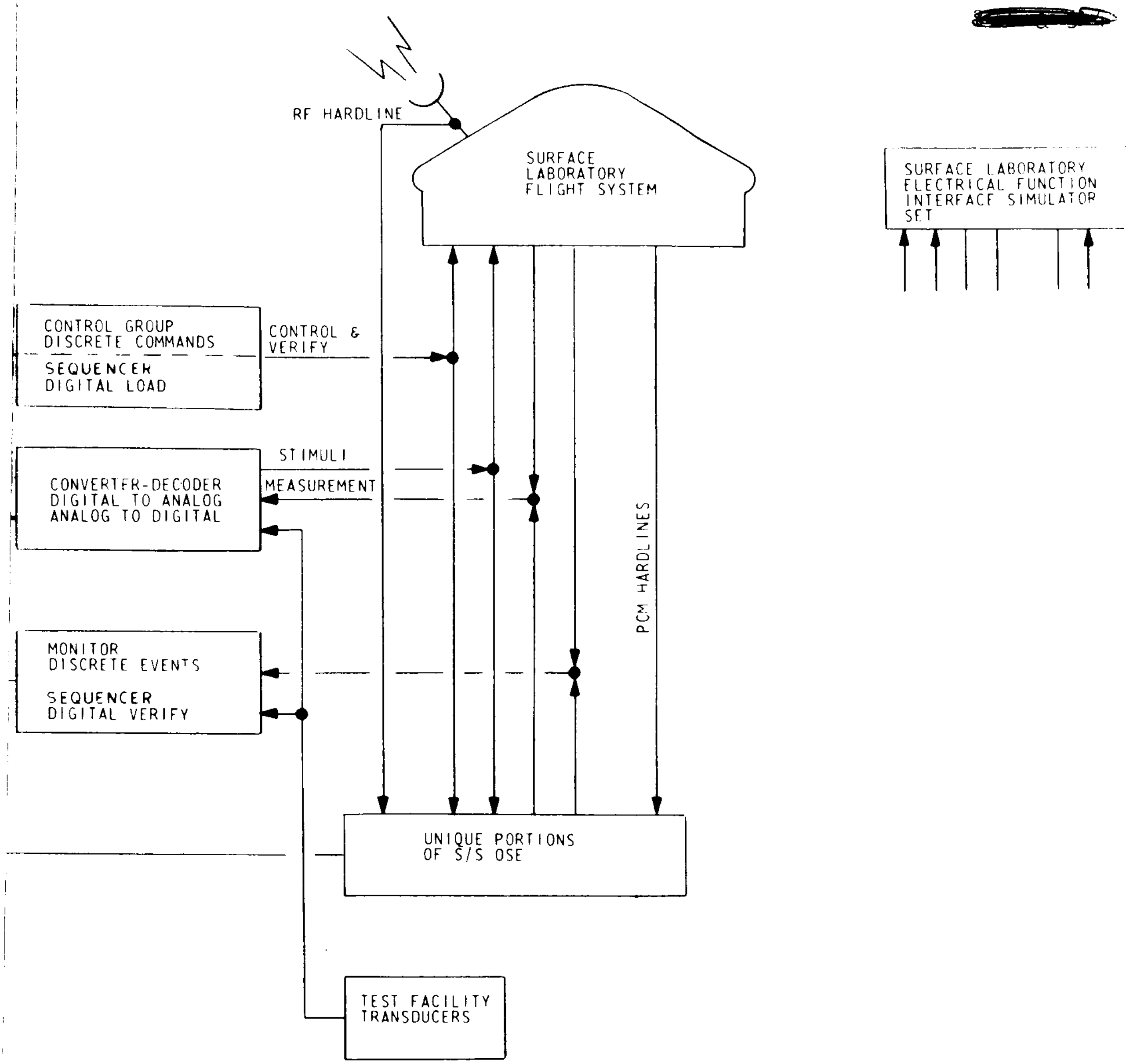
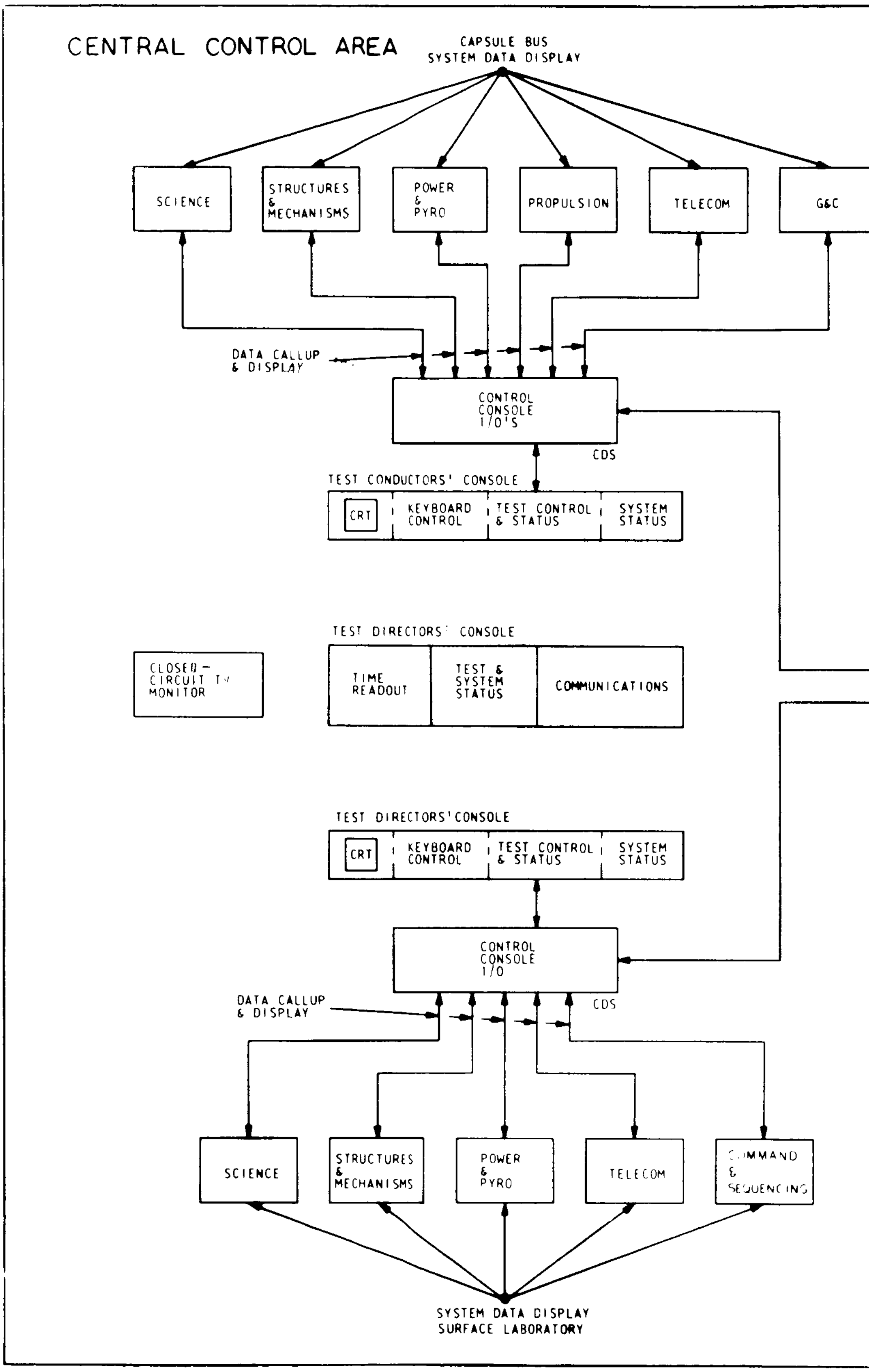
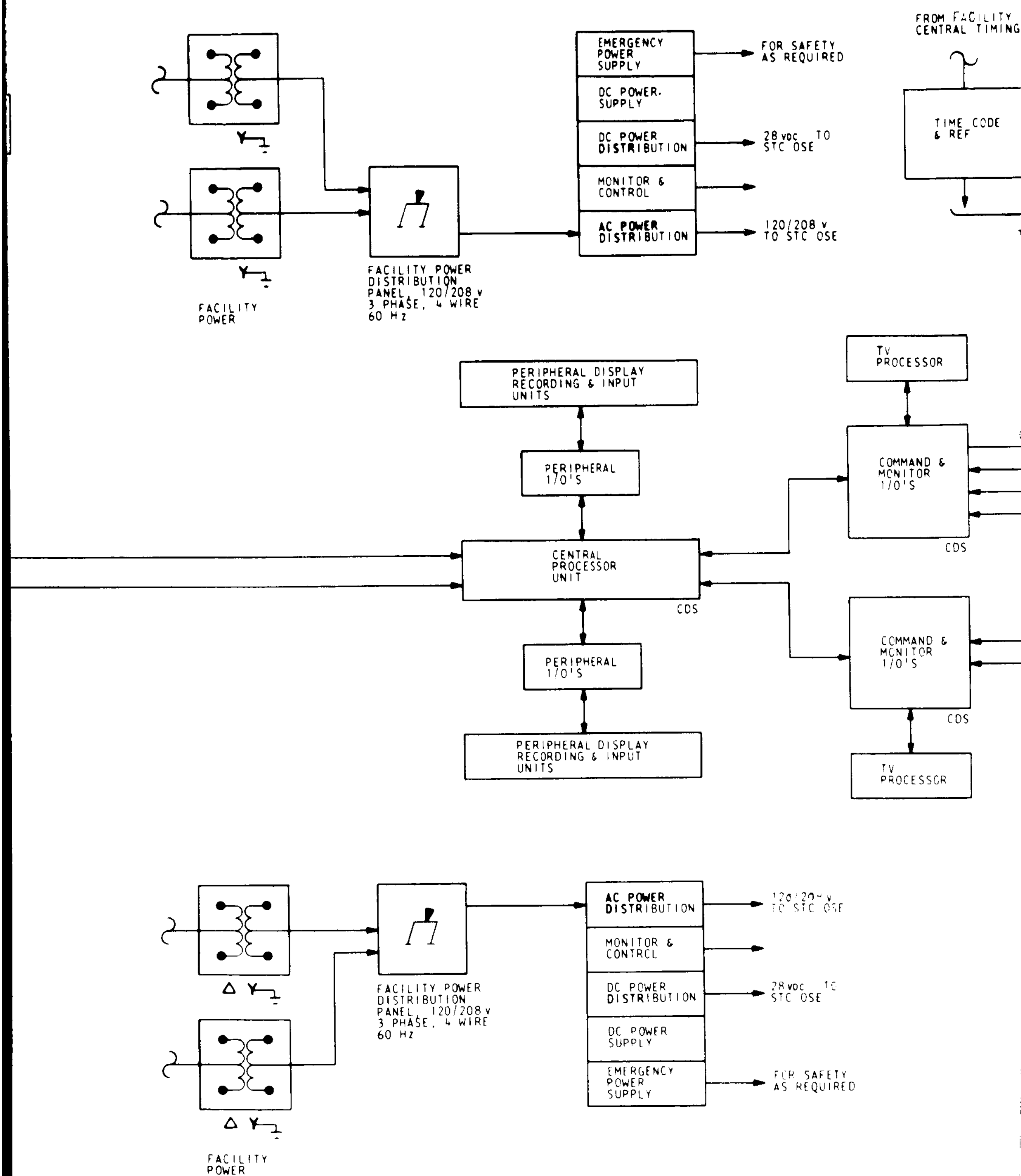

RF HARDLINE
SURFACE
LABORATORY
FLIGHT SYSTEM
SURFACE LABORATORY
ELECTRICAL FUNCTION
INTERFACE SIMULATOR
SET
CONTROL GROUP
DISCRETE COMMANDS
SEQUENCER
DIGITAL LOAD
CONTROL &
VERIFY
STIMULI
MEASUREMENT
CONVERTER-DECODER
DIGITAL TO ANALOG
ANALOG TO DIGITAL
PCM HARDLINES
MONITOR
DISCRETE EVENTS
SEQUENCER
DIGITAL VERIFY
UNIQUE PORTIONS
OF S/S OSE
TEST FACILITY
TRANSDUCERS


CENTRAL CONTROL AREA
CAPSULE BUS
SYSTEM DATA DISPLAY
SCIENCE
STRUCTURES & MECHANISMS
POWER & PYRO
PROPULSION
TELECOM
G&C
DATA CALLUP & DISPLAY
CONTROL CONSOLE I/O'S
CDS
TEST CONDUCTORS' CONSOLE
CRT
KEYBOARD CONTROL
TEST CONTROL & STATUS
SYSTEM STATUS
TEST DIRECTORS' CONSOLE
CLOSED-CIRCUIT TV MONITOR
TIME READOUT
TEST & SYSTEM STATUS
COMMUNICATIONS
TEST DIRECTORS'CONSOLE
CRT
KEYBOARD CONTROL
TEST CONTROL & STATUS
SYSTEM STATUS
CONTROL CONSOLE I/O
DATA CALLUP & DISPLAY
CDS
SCIENCE
STRUCTURES & MECHANISMS
POWER & PYRO
TELECOM
COMMAND & SEQUENCING
SYSTEM DATA DISPLAY
SURFACE LABORATORY

3-6-1


FROM FACILITY
CENTRAL TIMING
TIME CODE
& REF
EMERGENCY
POWER
SUPPLY
FOR SAFETY
AS REQUIRED
DC POWER
SUPPLY
DC POWER
DISTRIBUTION
28 VDC TO
STC OSE
MONITOR &
CONTROL
AC POWER
DISTRIBUTION
120/208 V
TO STC OSE
FACILITY POWER
DISTRIBUTION
PANEL, 120/208 V
3 PHASE, 4 WIRE
60 Hz
FACILITY
POWER
PERIPHERAL DISPLAY
RECORDING & INPUT
UNITS
PERIPHERAL
I/O'S
CENTRAL
PROCESSOR
UNIT
CDS
PERIPHERAL
I/O'S
PERIPHERAL DISPLAY
RECORDING & INPUT
UNITS
TV
PROCESSOR
COMMAND &
MONITOR
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120/208 V
TO STC OSE
MONITOR &
CONTROL
DC POWER
DISTRIBUTION
28 VDC TO
STC OSE
DC POWER
SUPPLY
EMERGENCY
POWER
SUPPLY
FOR SAFETY
AS REQUIRED
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PANEL, 120/208 V
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POWER

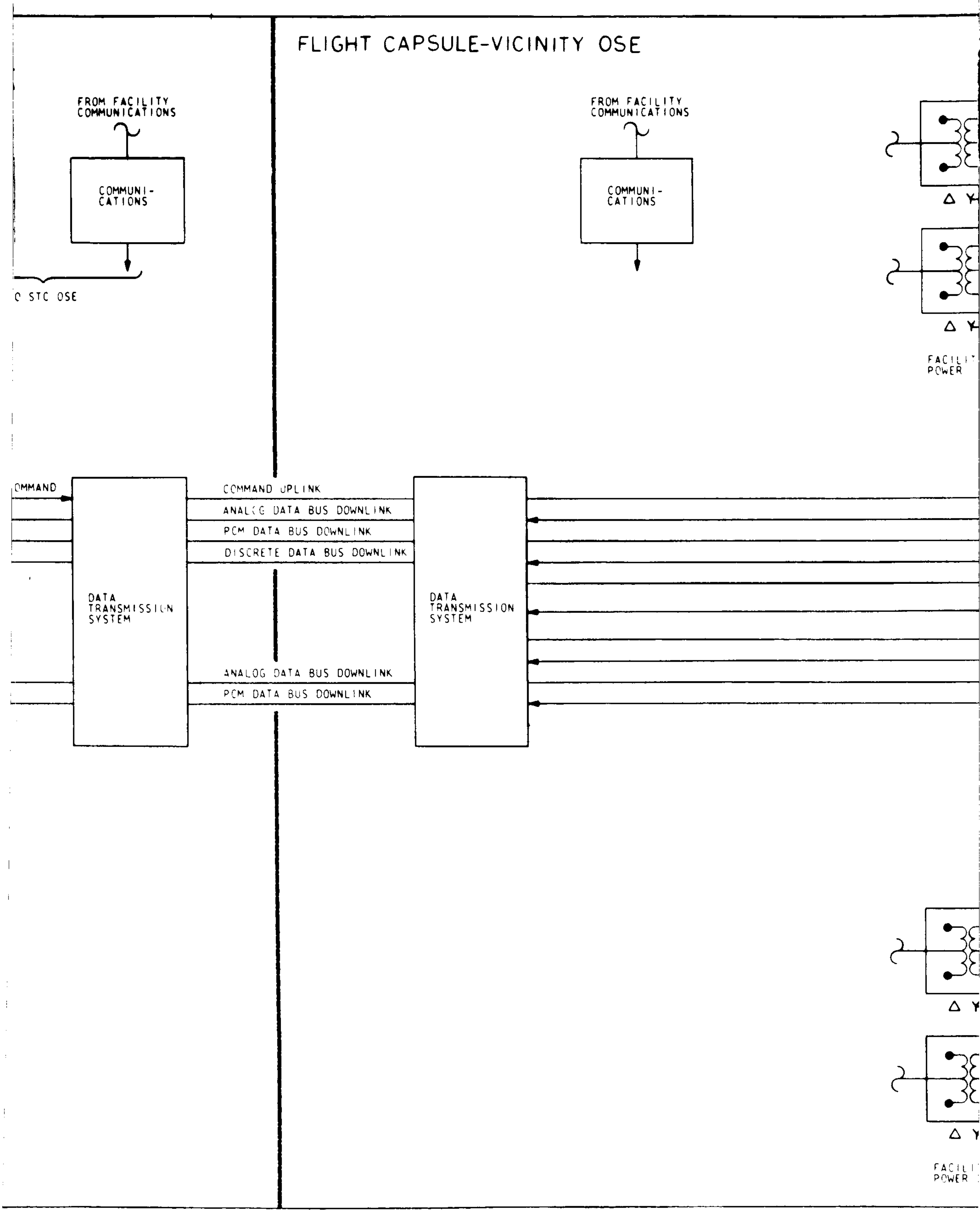
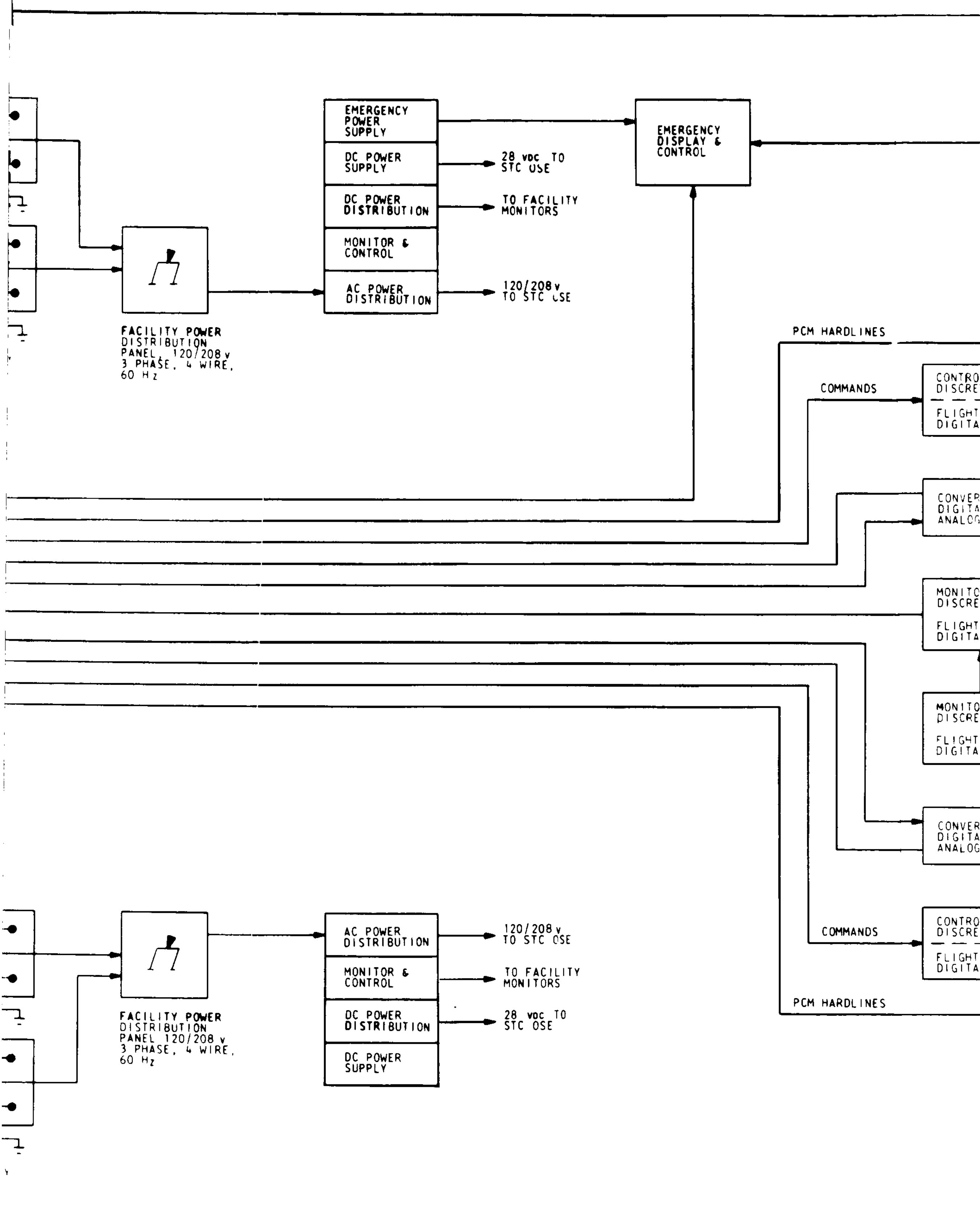

FLIGHT CAPSULE-VICINITY OSE
FROM FACILITY COMMUNICATIONS
COMMUNI-CATIONS
C STC OSE
FROM FACILITY COMMUNICATIONS
COMMUNI-CATIONS
FACILI POWER
OMMAND
DATA TRANSMISSION SYSTEM
COMMAND UPLINK
ANALOG DATA BUS DOWNLINK
PCM DATA BUS DOWNLINK
DISCRETE DATA BUS DOWNLINK
DATA TRANSMISSION SYSTEM
ANALOG DATA BUS DOWNLINK
PCM DATA BUS DOWNLINK
FACILI POWER

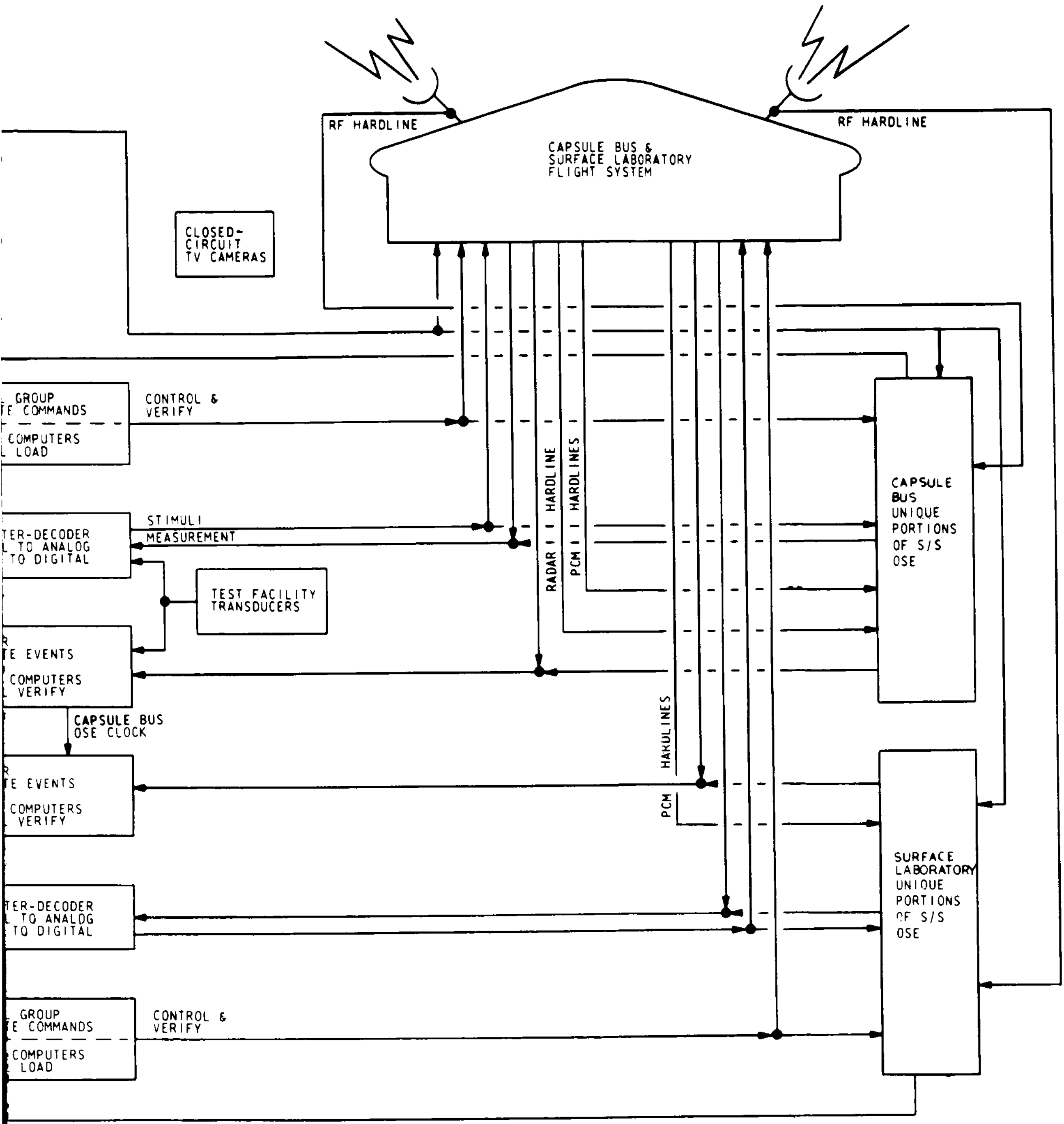
Fig. 3-2 Fligh

3-6-3



t Capsule STC Configuration

3-6-4



RF HARDLINE
RF HARDLINE
CAPSULE BUS &
SURFACE LABORATORY
FLIGHT SYSTEM
CLOSED-
CIRCUIT
TV CAMERAS
GROUP
E COMMANDS
COMPUTERS
LOAD
CONTROL &
VERIFY
TER-DECODER
L TO ANALOG
TO DIGITAL
STIMULI
MEASUREMENT
TEST FACILITY
TRANSDUCERS
RADAR HARDLINE
PCM HARDLINES
E EVENTS
COMPUTERS
VERIFY
CAPSULE BUS
OSE CLOCK
CAPSULE
BUS
UNIQUE
PORTIONS
OF S/S
OSE
HAKULINES
PCM
E EVENTS
COMPUTERS
VERIFY
SURFACE
LABORATORY
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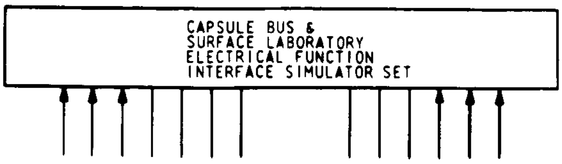
LOAD
CONTROL &
VERIFY


CAPSULE BUS &
SURFACE LABORATORY
ELECTRICAL FUNCTION
INTERFACE SIMULATOR SET

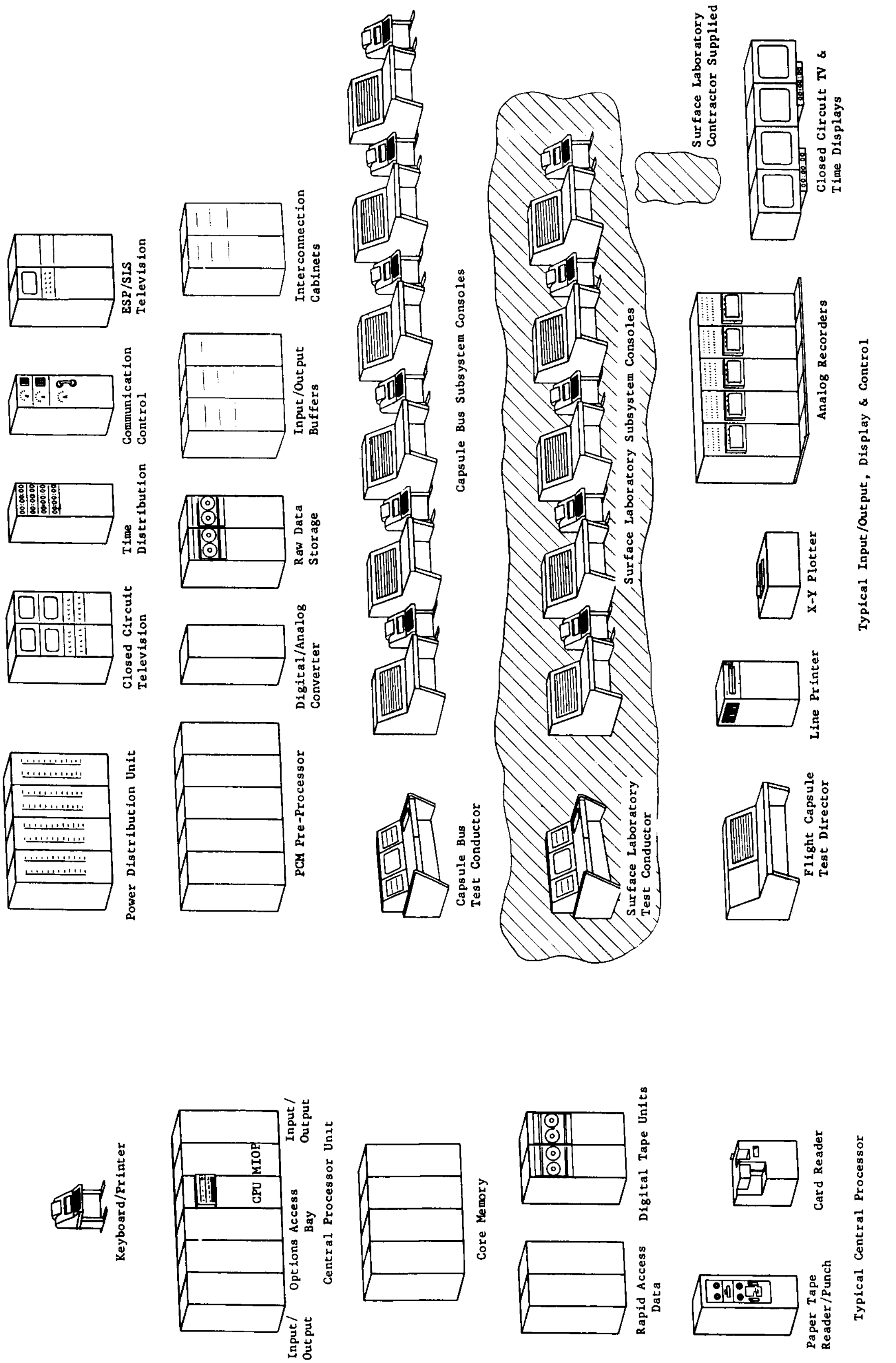


Fig. 3-3 Flight Capsule STC Control Center Equipment

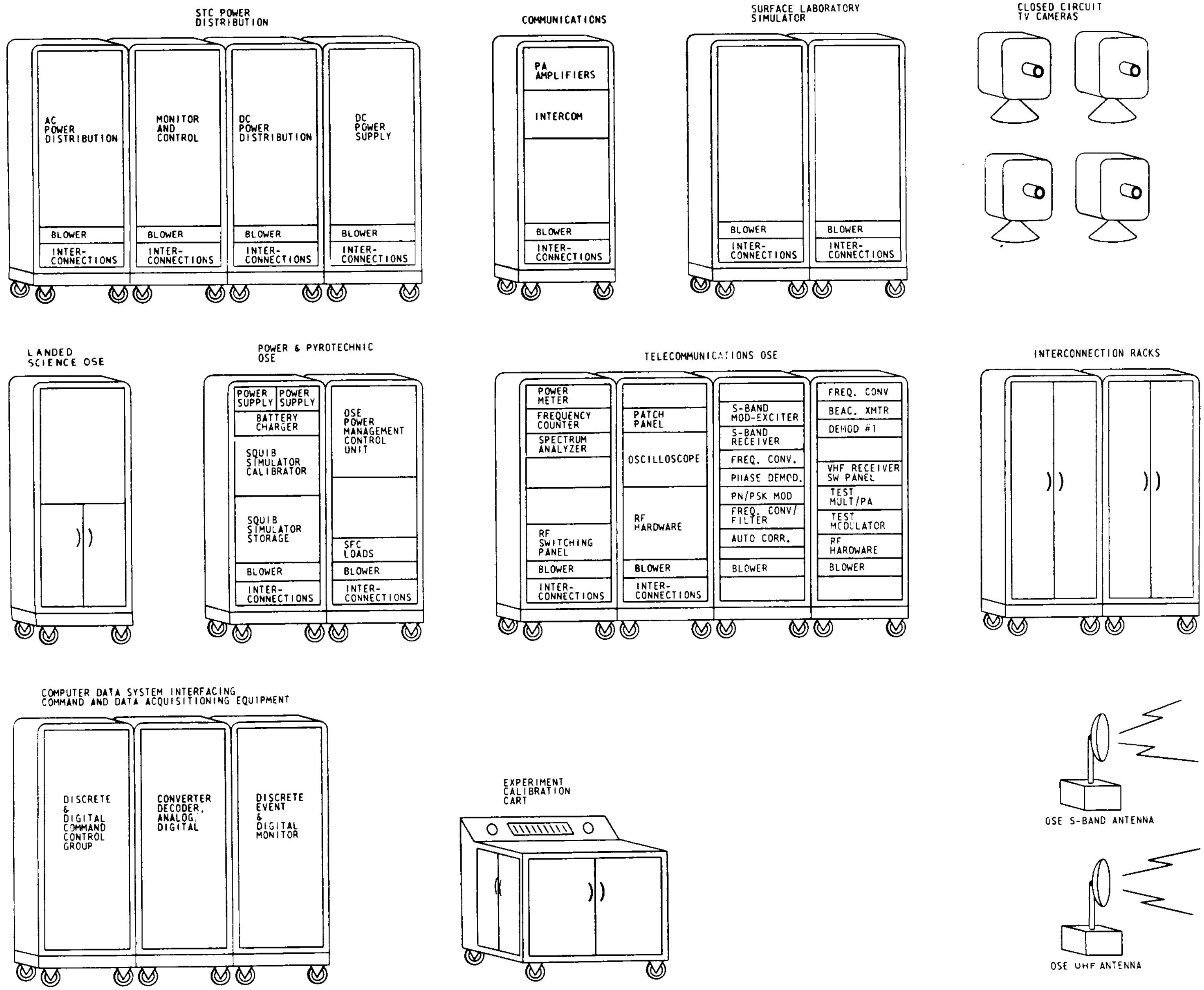


Fig. 3-4 Surface Laboratory-Vicinity OSE

Unique Subsystem OSE - This special-purpose equipment is required in addition to the computer command and data acquisition equipment for support and test of flight subsystems. It consists of selected assemblies of subsystem OSE.

Capsule Vicinity Ancillary - This equipment consists of power supply and power distribution, voice communication, timing and closed-circuit TV equipment.

3.2.1.2 STC Functional Capabilities and Philosophies

The following basic operational philosophies are identified for the STC:

1) The ability for complete qualification and acceptance testing of the Capsule Bus on a system level is provided, including testing of subsystems to the extent possible with available interfaces
2) Manual control of the Capsule Bus and its subsystems is accomplished centrally through the computer data system as initiated by a test conductor. This technique provides maximum configuration control of STC tests. Hardwired manual control functions are provided for emergency safing and off-on control at the system level. In general, the hardwired control capabilities are redundant with automatic and manual controls of the Computer Data System
3) Complex and extensive tests are automated through the computer system
4) The STCs ability to isolate faults to the flight subsystems, flight components, replacement-level packages or flight systems is limited only by the amount of flight system interface available in any given testing configuration.

   Normal available interfaces are direct-access connectors, flight cabling connectors, umbilicals, RF hardlines, RF open loop, and PCM and PDM hardlines.

   The majority of malfunctions are immediately flagged to the system and subsystem operators at their respective display stations.

   Anomalies or deviations from criteria for success as programmed in the computer data system are displayed on the CRTs, line printers, and teletypewriters.

   The flagging techniques used permit easily recognizable differentiation between anomaly data and status data.

   When malfunctions are flagged, available data either allow immediate identification or isolation of the faulty replacement item to the level of detection, or indicate what computer subroutines and other operational actions are required to complete the fault isolation function.

Self-test routines, continuous monitoring capabilities, and OSE test points are used in fault isolation of OSE equipment

5) Prerequisite logic, interlocks, redundancy and software controls are provided as safeguards to prevent the occurrence of damage to a Surface Laboratory, or any of its subsystems due to improper sequencing of test steps or due to STC element malfunction or failure
6) The Capsule Bus STC incorporates portions of the Entry Science Package OSE and Surface Laboratory STCs to form an integrated Flight Capsule System test capability.
7) STC equipment in conjunction with LCE is used to accomplish launch pad operations.

3.2.2 System Characteristics

The individual STC Operational Support Equipment is discussed in the following paragraphs.

3.2.2.1 Computer Data System (CDS)

The selected computer system is capable of testing three Surface Laboratory Systems or two Surface Laboratory Systems as parts of two Flight Capsule Systems at the same time. This system is capable of generating the required command and control signals, while continuously monitoring all pertinent Surface Laboratory and Flight Capsule input and output signals. Figures 3-3, 3-4 and 3-5 illustrate the functional and physical elements of the system.

The test conductor's console provides signals to the CDS to designate the types of tests to be performed and can cause test start, stop, repeat, recycle to a previous point. The stored program is then executed by generating the required commands.

All signals in and out of the Flight Capsule are stored in a raw data storage system capable of recording many data streams. Time codes are stored on one channel to ensure proper time tagging. There is an ability to replay this previous stored data into the CDS for further analysis.

The incoming data to the preprocessor undergoes compression operations that compare the new data to previous samples. Only data that differ significantly are retained and further processed. These significant data are tagged with appropriate identifiers as they are placed in storage.

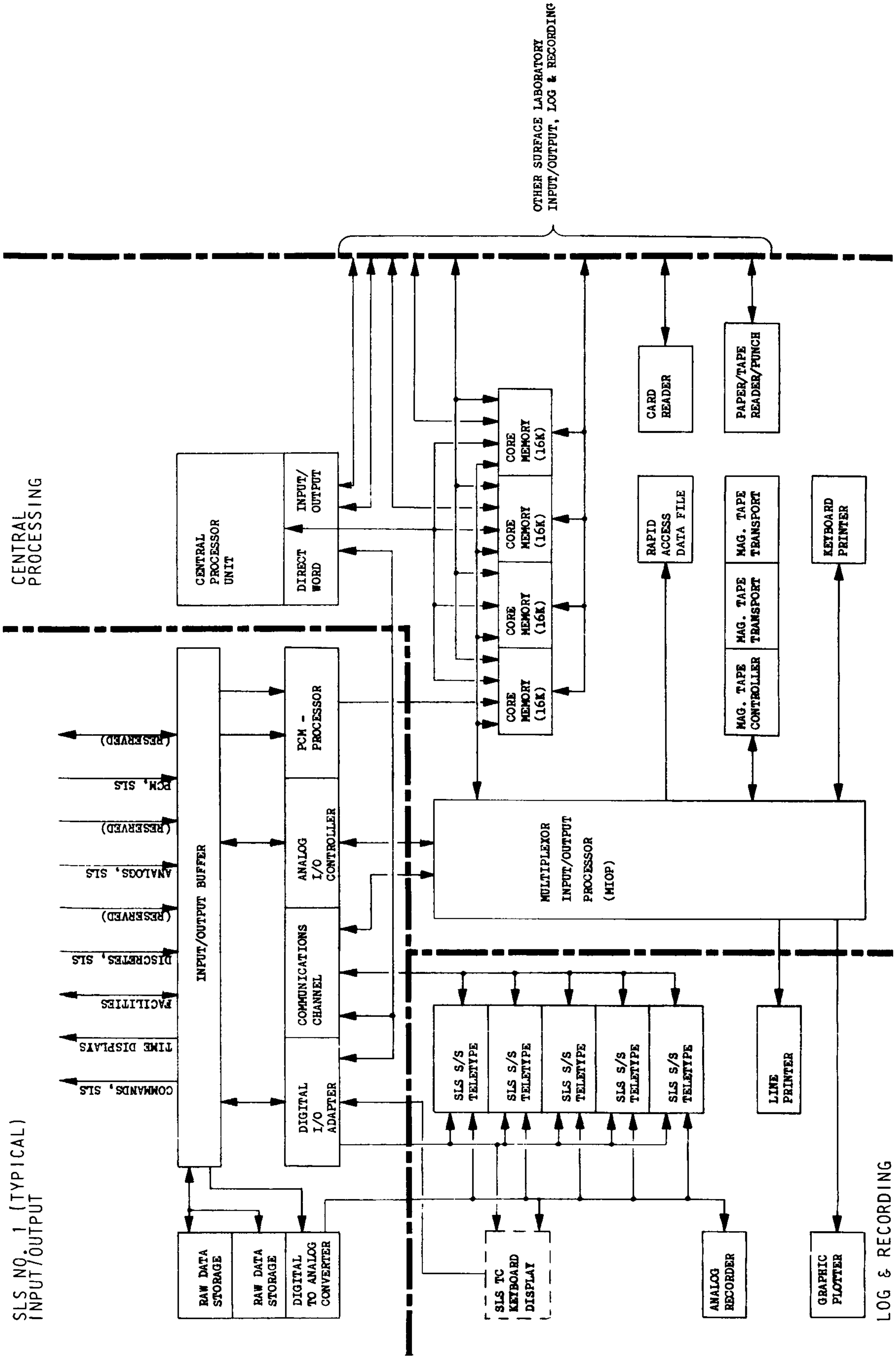


Fig. 3-5 Surface Laboratory Computer Data System Block Diagram

The criticality of each signal has been predetermined, so that the central processor proceeds to take the appropriate action. For alarm monitoring, appropriate safing or test interruption, action takes place immediately and has the highest priority for central processor servicing. The test conductor and the subsystem operator are notified and an alarm is sounded if the condition is hazardous. Out-of-limits data cause subroutines to further isolate the malfunction or indicate the action to be taken.

All No-Go data, including alarm conditions, are printed on a line printer for a master log of the test data. This printout includes the time of occurrence, channel designator, actual reading (in engineering units), assigned upper and lower limits, and the condition of other data associated with this situation.

Some non-alarm compressed data are selected for use by the test conductor or subsystem operator for display on the appropriate consoles and can also be printed as part of the master log. Some compressed data are selected for trend analysis. Trend prediction is employed, which uses extrapolation and curve fitting of previous samples to estimate the expected, within tolerance, life span of a component or subsystem.

Compressed or uncompressed data can be selected by the processor for real-time recording. The processor assigns the digital/analog converter (DAC) channel to the recorder channel and to the analog indicators on the display consoles.

All signals are verified and recorded as they are sent to the Flight Capsule Systems as a means of self-testing, in addition to other continuous self-tests that monitor the performance of commands through decoding phases. If a potentially hazardous signal is selected, then the signal setup would be verified before an execute command is issued by the CDS. Fault-isolation self-testing routines are called up as part of a procedure or during initialization periods to determine proper operation of the OSE.

The CDS equipment required to perform these tasks is subdivided into three groups:

1) Log and recording equipment
2) The central processing equipment
3) Input/output equipment.

The reference configuration for testing two Flight Capsules is discussed followed by the alternative configurations.

<u>Log and Recording Equipment</u> - The log and recording equipment (Fig. 3-5) to fill the man-machine interface requirements for testing of Voyager Flight Capsules is described in the definition of the group and its physical characteristics.

Subsystem Definition - The log and recording equipment grouping provides four types of printed data for the test director, test conductor, or subsystem operators. The display data can be preprogramed to be printed under specific conditions or some data can be called up with console instructions.

The teletypewriter hardcopy is printed pages at the disposal of each subsystem operator and a unit is assigned to each subsystem operator's console. The characters are printed at a rate of 10 characters per second, which provides 10 lines of data in approximately one minute.

The line printer prints data much faster, so this is used for the master log of the test data. The line printer prints a complete line at a time (up to 132 characters) at 600 lines a minute on hardcopy paper.

The X-Y plotter (graph plotter) plots discrete points in 0.01-in. increments in the X and Y axes at 18,000 line segments per minute on 12-in. wide paper up to 120 ft long. The plotter is used to display one variable as a function of another.

The direct writer recorders are used to observe variation of signals as a function of time with eight 40-mm recorder channels per paper roll. The channel frequency response is flat to 55 cps and the chart speed is selectable in 12 ranges from 02 to 100 mm/sec. Five of these recorders support each Flight Capsule or Surface Laboratory.

Physical Characteristics - The log and recording equipment is installed in the same area as the other control center OSE (Fig. 3-3), e.g., the test director's console, and the test conductor's consoles, and the subsystem consoles.

1) The teletypewriter is a keyboard/printer 40 in. high, 20 in. wide and 24 in. deep
2) The line printer is a single unit 53 in. high, 39 in. wide and 25 in. deep
3) The graph plotter is mounted on a table 2 1/2 by 5 ft
4) Each of the five analog recorders is housed in one rack.

Central Processing Equipment - The central processing equipment consists of a high-speed general-purpose digital computer and its associated devices. This equipment accepts commands and data from the input/output group, processes the incoming information, stores necessary data and provides signals to the display groups for indicating the results.

Subsystem Definitions - Scientific Data Systems (SDS) Sigma computer, because of its unique ability to work in a real-time environment, was selected as a reference for this phase of the program. The central processor's main task is to perform real-time monitoring, decision making and command execution. This task is performed by the use of normal sequences of programs in the computer memory. Also, the test conductor can alter some of the test conditions such as nonhazardous limits or test sequences. A secondary task is to reduce data acquired in the real-time process. This background process proceeds nearly concurrent with the real-time process, but in no way degrades or conflicts with the real-time duties.

The selection of the Sigma Central Processor was based on the following salient features considered necessary for a real-time application: 850-ns memory cycle time, word-oriented memory (32 bits) addressable and alterable by byte (8 bits) half word, word, and double word; concurrent input/output and computations; flexible input/output system; priority interrupt system with automatic hardware identification, allowing Sigma to change its complete operating environment in 6 μsec or less, with program-controlled enabling, arming, and triggering.

The magnetic core memory group comprises four blocks of 16k words but is expandable up to eight 16k-word blocks, in 4k-word increments, with a "memory protect" capability. The four core memory blocks will service two Flight Capsules or three Surface Laboratories.

The rapid access data (RAD) file is a mass storage device that can store large volumes of information with an average access time of 17.5 ms. The rapid access data file unit has a capacity of 24 million bytes, but can be readily expanded up to 188 million bytes.

The digital tape recorders are used in a test to store compressed data of test results and any additional data displayed on the line printer log. The digital tape memory units will transfer 60,000 bytes of data per second with 9-track format.

The basic programs or data tables will be initially loaded into the computer by a card reader (or magnetic tape units) for off-line operations. Four hundred cards per minute can be read by the photoelectric reader.

The keyboard/printer can provide instructions to the computer to set up and maintain the central processor. This unit has the same functional characteristics as the teletypewriter described in paragraph 3.2.2.1.

The paper tape reader/punch is used for preparation and loading of the subsystems that require changes from one test program to another. The photoelectric reader reads paper or mylar tape at a speed of 300 characters per second, and prints at a speed of 120 characters per second; and can do so at any of three standard tape widths.

The multiplexer input/output processor (MIOP) moves the data in and out of memory to the peripheral devices. The MIOP operates under instructions stored in memory and initiated by the central processor. The MIOP is used to handle the input/output operations between the core memory and the standard peripheral equipment or the input/output units.

Physical characteristics - The Central Processor group is near the control and display area and has the following characteristics:

1) Central processor unit - housed in three standard computer-sized cabinets 30 in. wide
2) Multiplexer input/output processor (MIOP) - all required are housed in a single computer-type cabinet
3) Magnetic core memory group - each of the four memory blocks is in a standard computer cabinet
4) Rapid access data (RAD) - in two computer-sized cabinets per each Flight Capsule
5) Digital tape memory unit - each of the two units per Flight Capsule is housed in one computer-type rack
6) Card reader - 42 in. high, 32 in. wide, and 25 in. deep
7) Paper tape reader/punch - single computer rack unit located within 30 ft of the MIOP
8) Keyboard/printer - One teletypewriter-sized unit is required.

Input/Output Equipment - The input/output group accepts signals from the central processor for transmission to or from the Capsule-vicinity equipment via the data transmission system. The timing and facility type signals are also processed by this group of equipment.

Subsystem Definitions - This group of equipment is composed of circuits to buffer and condition all input and output signals to make them compatible with the requirements. The characteristics of each unit in this group are described below:

1) Input/output buffer - contains the signal conditioning, buffering and signal conversion equipment
2) Accessories equipment - contains the digital input/output adapter circuits and the analog input/output (I/O) controller. The digital I/O converts the test conductor commands for processing and provides driving capabilities for relay or lamp operations. The analog input/output controller provides control for operation of analog devices
3) Communication channel controller - controls the signal flow to and from teletypewriters or keyboard/display
4) Raw data storage - magnetic tape recorder units with 14 tracks that operate up to 120 ips. All interfaces are stored on magnetic tape except the status and analog displays to allow replay of these signals
5) Digital/analog converter - provides up to 48 analog signals to analog displays or recorders, as well as 12 bilevel converter channels for lamp indications addressable by the computer
6) PCM preprocessor - relieves the central processor of much of the heavy load by PCM decommutation and data compression using this general-purpose PCM preprecessor. The I/O unit not only acquires sync without loss of presync data, but identifies errors, restores degraded signals, counts errors, and suppresses insignificant data. This preprecessor operates by stored program just like the central processor, but seldom interfers with the central unit. This PCM preprocessor handles two PCM data channels simultaneously or accepts one PCM channel and one PAM/PDM channel. The maximum data rates per channel are 128,000 words/sec for PCM, 100,000 words/sec PAM, or 10,000 words/sec PDM. A PCM/PAM/PDM simulator is also in this unit to generate simulated signal levels and degradation.

Physical Characteristics - It is not necessary to install this group in the immediate area of the other two groups, except for the PCM preprocessor, which needs to be installed as close as possible to the memory bank. The physical characteristics of the group are:

1) Input/output buffer - housed in three standard racks
2) Accessories equipment - housed in a single computer rack
3) Communication channel controller - contained in one computer-type rack
4) Raw data storage - in two single rack recorders, one for recording and one for transfer when the first unit is full
5) Digital/analog converters - in a single-rack unit to service each Flight Capsule
6) PCM preprocessor - consists of five computer-type cabinets.

Alternative Configuration - A variation of the reference CDS configuration is the addition of some peripherals when three Surface Laboratories are tested with one CDS.

Subsystem Definition - The "three Surface Laboratories per CDS" configuration is identical to the "dual" configuration except that the equipment assigned to the third Surface Laboratory is added. This added equipment consists of the total input/output group, the total log and recording group and parts of the central processor system including one RAD, two tape transports and two MIOP's.

Physical Characteristics - The amount of equipment added for a three Surface Laboratory configuration is 33 units; 18 of which comprise the display and control group; 12 can be added to the input/output group and 3 can be added to the central processor.

Supplemental Equipment - This configuration is an expansion of the reference to allow program preparation.

Subsystem Definition - The program preparation unit is used with any STC configuration to allow the preparation or modification of test programs and procedures(as a background program). The supplemental equipment required is:

1) Keypunch
2) Card verifier
3) Card sorter
4) Card punch
5) Two additional tape transport units.

Physical Characteristics - The supplemental program preparation equipment added to an STC CDS is four consoles and two computer cabinets.

3.2.2.2 Control Center Control and Display OSE

The control center control and display OSE permits operating and test personnel to communicate with and maintain control of system test operations and obtain data for evaluation of the Surface Laboratory System, OSE, and facility performance.

Test Conductor's Console - The definition and characteristics of this console are discussed below.

Subsystem Definition - The test conductor's console provides the man-machine interface with the computer system and OSE hardware for initiating and controlling testing of the Surface Laboratory or any of its subsystems.

1) Real-time displays and controls are provided for test control and evaluation of significant test conditions and system performance during testing, for isolating sources of malfunctions, for initiating and monitoring of system self-test, for displaying Surface Laboratory, OSE, and test facility status, for initiating and controlling tests in automatic, semiautomatic and manual modes.
2) The ability to modify existing tests or test sequences and alter stored data compression limits is provided
3) Manual safing of the system is provided independent of the computer, in case hazardous conditions occur during testing.

Physical Characteristics - The test conductor's console is a three-bay sitdown console capable of one man operation. See Fig. 3-6 for a general layout of displays and controls. The console includes a CRT display for real-time monitoring of data, a time readout display, a communications panel, and the test conductor's display and control panel.

System Display Groups - The definition and characteristics of these groups are discussed below:

Subsystem Definition - The systems display groups provide real-time display capability for the Surface Laboratory subsystem-oriented test analysis teams to evaluate subsystem performances during normal test and troubleshooting operations.

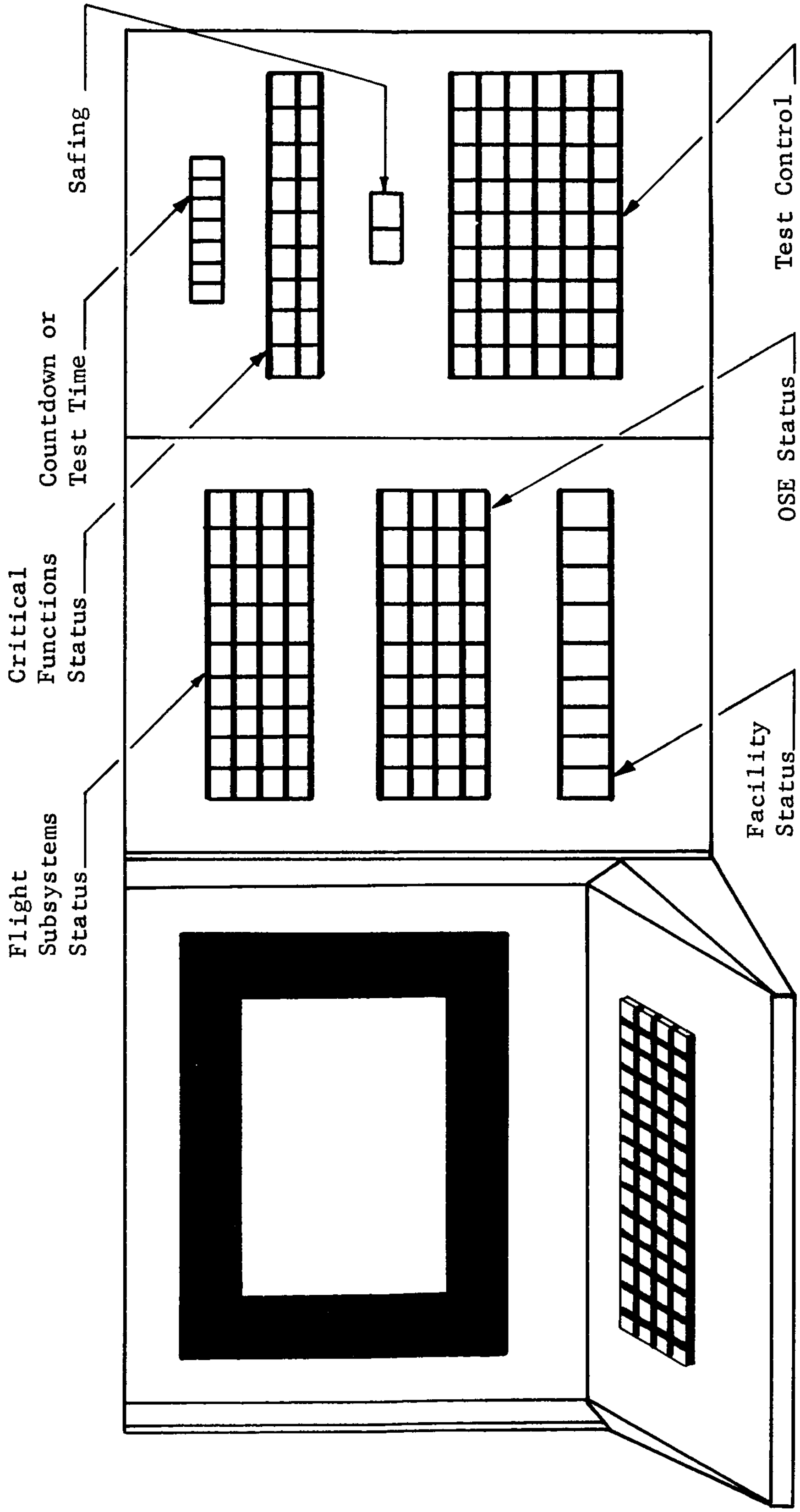


Fig. 3-6 Test Conductor's Display and Control Panel

The systems display groups are capable of:

1) Providing real-time displays for evaluation of significant test conditions and performance of Surface Laboratory subsystems during testing and for isolating sources of malfunctions to and within the subsystems
2) Calling up data related to the subsystem grouping
3) Displaying test time or countdown time
4) Containing intercommunication equipment.

Physical Characteristics - Each system display group consists of a multibay console and a teletypewriter. The console contains a time readout display and a communication panel. Desk top space is provided for drawings, procedures, and other technical material. Special-purpose displays unique to the subsystem can be accommodated.

Surface Laboratory Television Data Processing and Display Equipment - This equipment is discussed below:

Subsystem Definition - The television data processing and display equipment provides the electronics, visual display, and photographic processing equipment required to complement the computer data system in the evaluation of the flight television vidicons and electronics during system testing in the STC.

Equipment is shared for Entry Science Package and Surface Laboratory television tests in Flight Capsule STCs.

The television data processing and display equipment provides:

1) Control electronics
2) Decommutation and data stripping of identification, sync, and video data
3) Scan generation synchronizing, deflecting and blanking
4) Identification formatting, displaying and optics
5) Video signal conditioning, CRT display, optical lens and film/film processing
6) Power supplies
7) OSE self-test equipment.

Physical Characteristics - The television data processing and display equipment consists of two standard racks plus photographic processing, enlarging, and projecting equipment. The design is identical to that used for subsystem OSE and MDE.

3.2.2.3 Surface Laboratory-Vicinity OSE

The Surface Laboratory-vicinity OSE interfaces directly with the Surface Laboratory for control and monitoring of Flight Capsule subsystems. The equipment is capable of generating analog, digital and discrete signals under control of the computer command system for stimulating and controlling the Surface Laboratory and in processing these signals for transmission to the computer data system. The equipment contains the special-purpose subsystem OSE required to operate and support system and subsystem testing in the STC.

Discrete & Digital Command Control Group - Subsystem definition and characteristics are discussed below:

Subsystem Definition - The discrete and digital command control group interfaces directly with the Surface Laboratory and with items of STC OSE for effecting discrete and digital control of Surface Laboratory subsystems and of OSE testing operations as commanded by the computer system. Figure 3-7 is a functional block diagram of the group.

The discrete and digital command equipment provides:

1) For receiving biphase digital data information as transmitted from the control center
2) Device selection, parity check, function decoding, address decoding, memory, and relay switching for each discrete output control
3) Necessary controls, interlocks, and prerequisites to prevent operation of any flight subsystems or OSE hardware that could be damaged or destroyed by improper application of power, out-of-limits temperatures, or other such characteristics
4) Signal conditioning and buffering of digital data loading of flight computers and sequences
5) Ability to interface with the discrete events monitor unit for OSE testing and OSE self-check
6) Ability to interface with other STC OSE to effect command control of test operational modes, power application and removal cycles, and simulation controls
7) The internal power supply capability needed to support internal rack circuitry-unique power requirements.

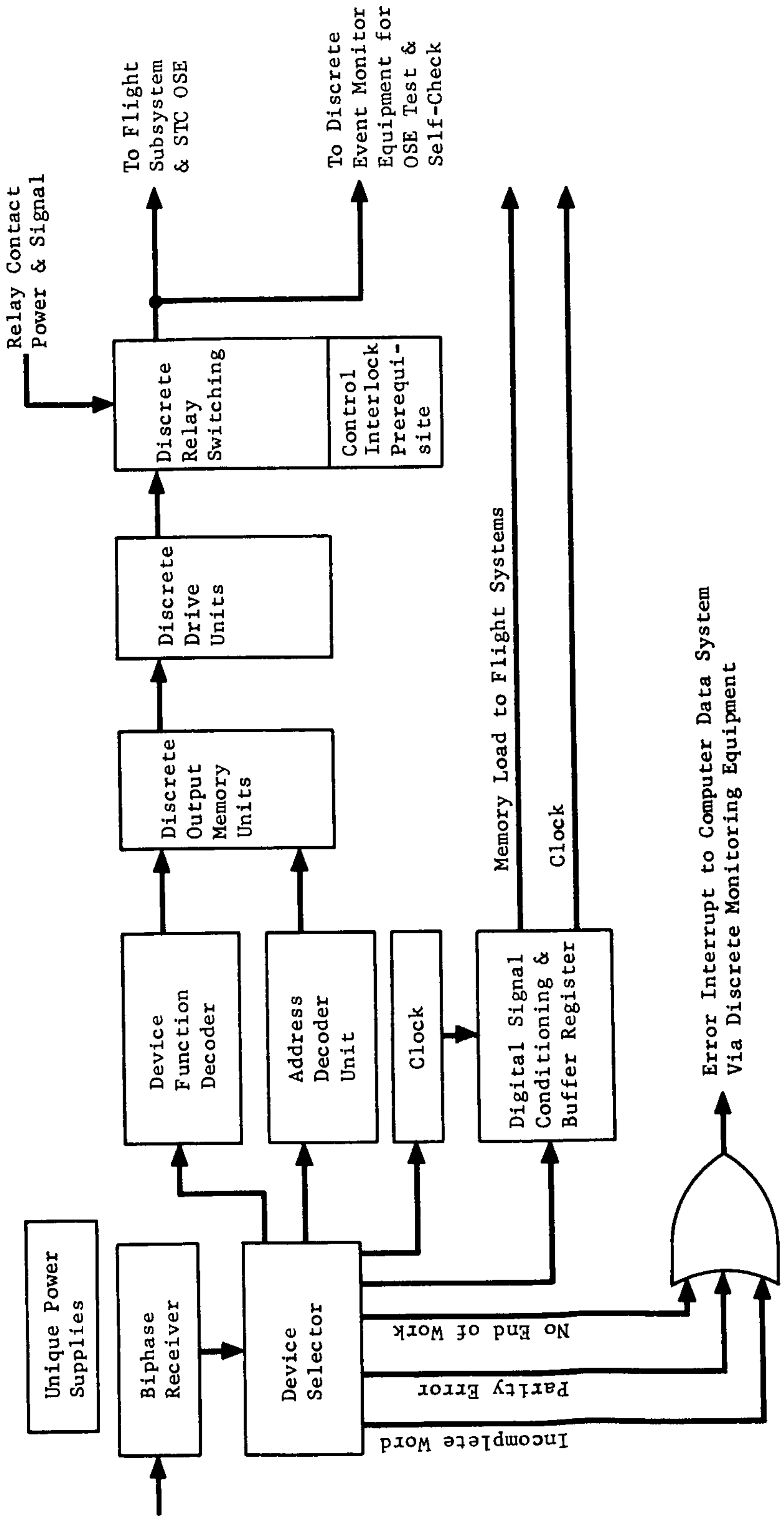


Fig. 3-7 Discrete and Digital Command Control Group

Physical Characteristics - The functional requirements are met by the use of basic OSE hardware building blocks. These building blocks are modular electronics designs of items such as device selector units and discrete output units, which are compatible with subsystem OSE use as well as STC-OSE use.

The discrete and digital command control group consists of one standard rack of equipment.

Digital/Analog Converter-Decoder - The definition and characteristics of this equipment are discussed below.

The digital/analog converter-decoder interfaces directly with the Surface Laboratory for providing stimulus to the Flight Capsule subsystems and for acquiring Flight Capsule and OSE analog data for transmission to the computer data system (Fig. 3-8).

The digital/analog converter-decoder, provides:

1) Receiving digital data information transmitted from the control center on the biphase transmission lines
2) Programing digital-to-analog converters (D/A) by using digital words received over the data transmission system
3) D/As as required to meet subsystem and system test requirements in the System Test Complex
4) Decoding of digital words received over the data transmission system for analog switching including device selection, function decoding, address decoding and parity checking
5) Memory, drive capability, and relay switching for each direct-access and umbilical analog switching point of the Flight Capsule subsystems
6) Ability to interface the output of the D/As with the analog data acquisitioning equipment for D/A verification before energizing the analog addressing switch
7) Signal conditioning of analog signals as received from the direct access and umbilical connectors
8) A multiplexing system and analog-to-digital conversion of the analog signals
9) A digital data transmission system transmitter (biphase modulator, line driver and interfacing equipment).

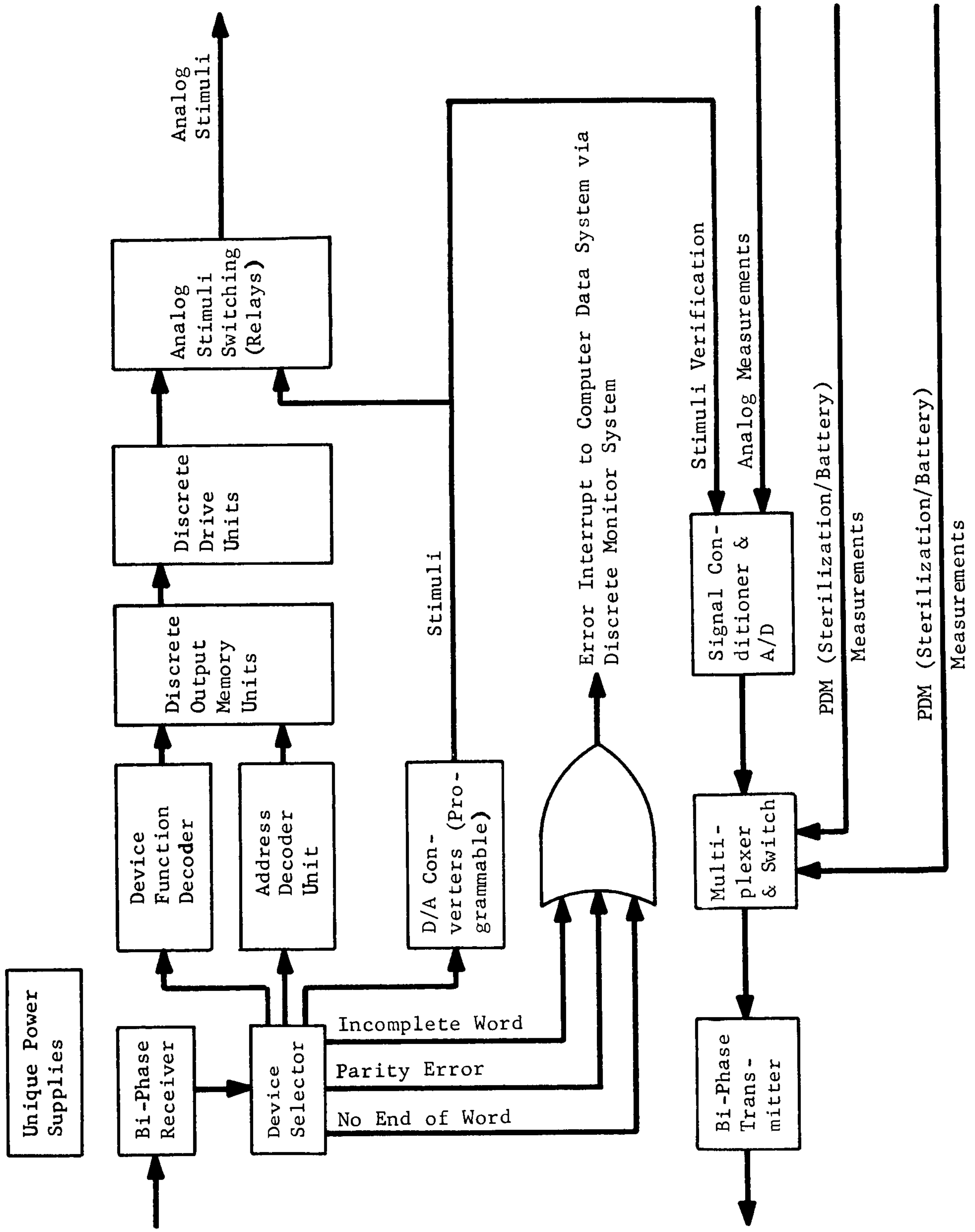


Fig. 3-8 Digital/Analog Converter-Decoder

Physical Characteristics - The functional requirements are met by the use of basic OSE electronics hardware building blocks. These building blocks are modular designs of items such as device selection units, discrete output units and D/As, which are compatible with subsystem OSE use as well as STC-OSE use.

The digital/analog converter-decoder, consists of one standard rack of equipment.

Discrete Event and Digital Monitor - This monitor is discussed below:

Subsystem Definition - The discrete event and digital monitor interfaces directly with the Surface Laboratory and with items of STC OSE for effecting discrete and digital signal detection for computer system data acquisition (Fig. 3--9).

The discrete event and digital monitor equipment provides:

1) Accepting all flight system and STC OSE discrete signals
2) Signal conditioning, discrete detection, and scanning of each discrete signal
3) A scanner multiplexer system for clocking, synchronizing, and addressing the discrete signal scanners
4) A digital data transmission system biphase transmitter
5) Ability to isolate input discrete detection circuits to maintain power supply grounding isolation
6) Signal conditioning and buffering received digital data
7) Switching required to allow the discrete event transmission line to be used for transmitting the flight sequence digital data. Verification of digital loading is on a time-shared basis with the discrete events
8) For including standard system designs for all internal power requirements except where unique voltages are needed.

Physical Characteristics - The scanner multiplexer system consists of proven equipment designs as used on the Titan III programs.

The discrete event and digital monitor consists of one standard rack of equipment.

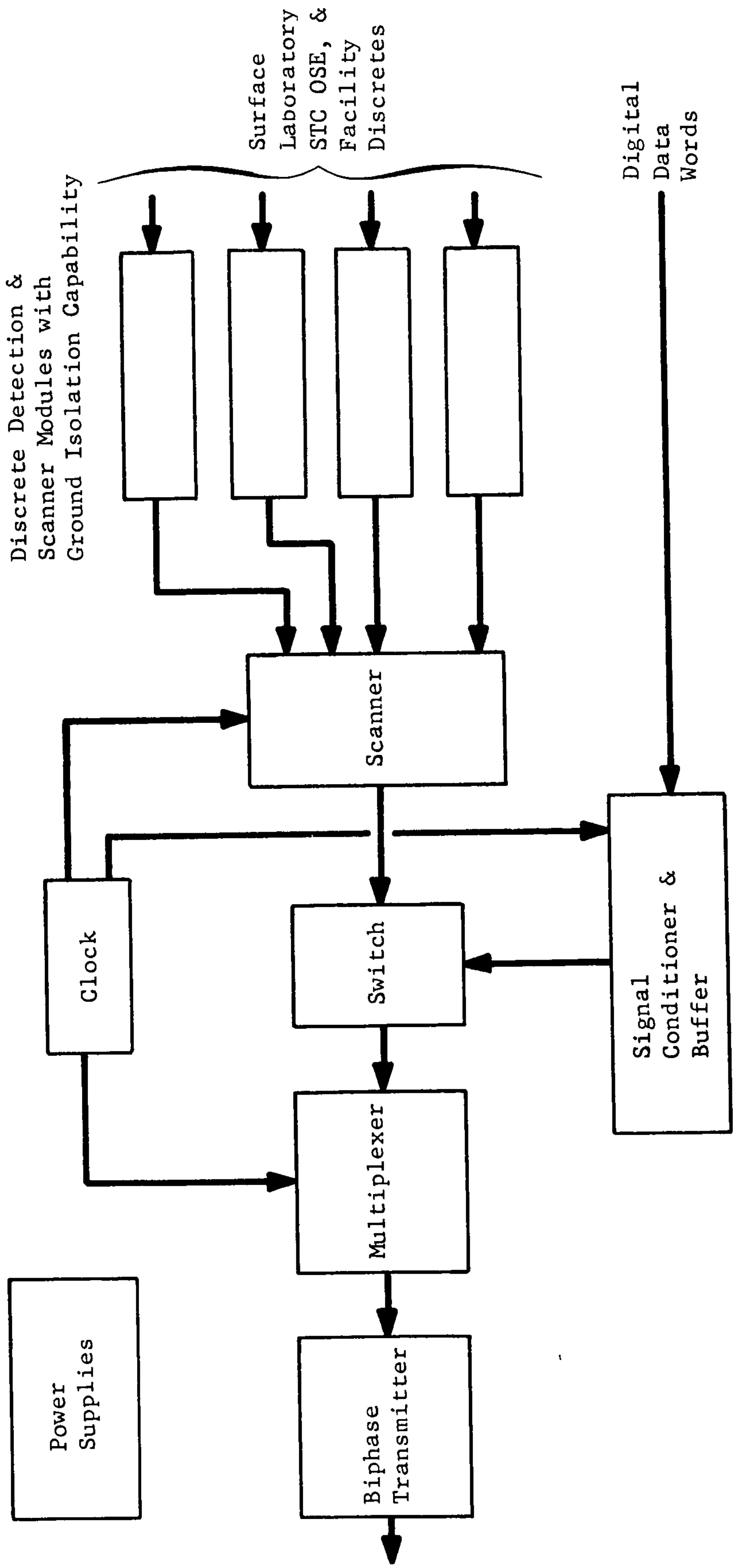


Fig. 3-9 Discrete Event and Digital Monitor

Surface Laboratory STC, Power & Pyrotechnic OSE - This equipment is discussed below.

Subsystem Definition - The STC power and pyrotechnic OSE in conjunction with the STC command and data acquisition equipment provides the equipment required to support and test the power and pyrotechnic subsystems in the STC (Fig. 3-10).

The Surface Laboratory STC power and pyrotechnic OSE provides:

1) Battery formation charging for charging flight-type batteries used during system testing and for flight batteries post-sterilization
2) Spacecraft power simulation to simulate power supplied to the Surface Laboratory from the Spacecraft
3) Surface Laboratory power simulation to simulate flight batteries
4) An OSE power management control unit for control and switching all OSE simulated power and battery charging power to the Surface Laboratory. Interface provisions for automated computer system control of power application and removal. The OSE contains the displays necessary to accomplish efficient manual control of power status. Interface with the data acquisition equipment is provided to effect power status display in the control center.
5) Squib simulators to simulate flight pyrotechnic squibs. A separate device is provided for each squib circuit. The simulator indicates a successful test only if adequate power is delivered to each squib circuit to ensure an "all fire" margin. The simulator provides protection to prevent current-limiting resistor burnout after firing. The simulators provide discrete signals to the discrete event and digital monitor equipment for transmission to the computer data system. The STC OSE provides storage for the simulation units. Calibration equipment is provided.

Physical Characteristics - The STC power and pyrotechnic OSE uses designs identical to those of the subsystem OSE, where practical. Repackaging is accomplished where required to fulfill STC compatibility requirements and for efficiency. The power simulator consists of variable electronic current-limited power supplies variable over battery charge/discharge limits to permit parametric testing of Surface Laboratory subsystems.

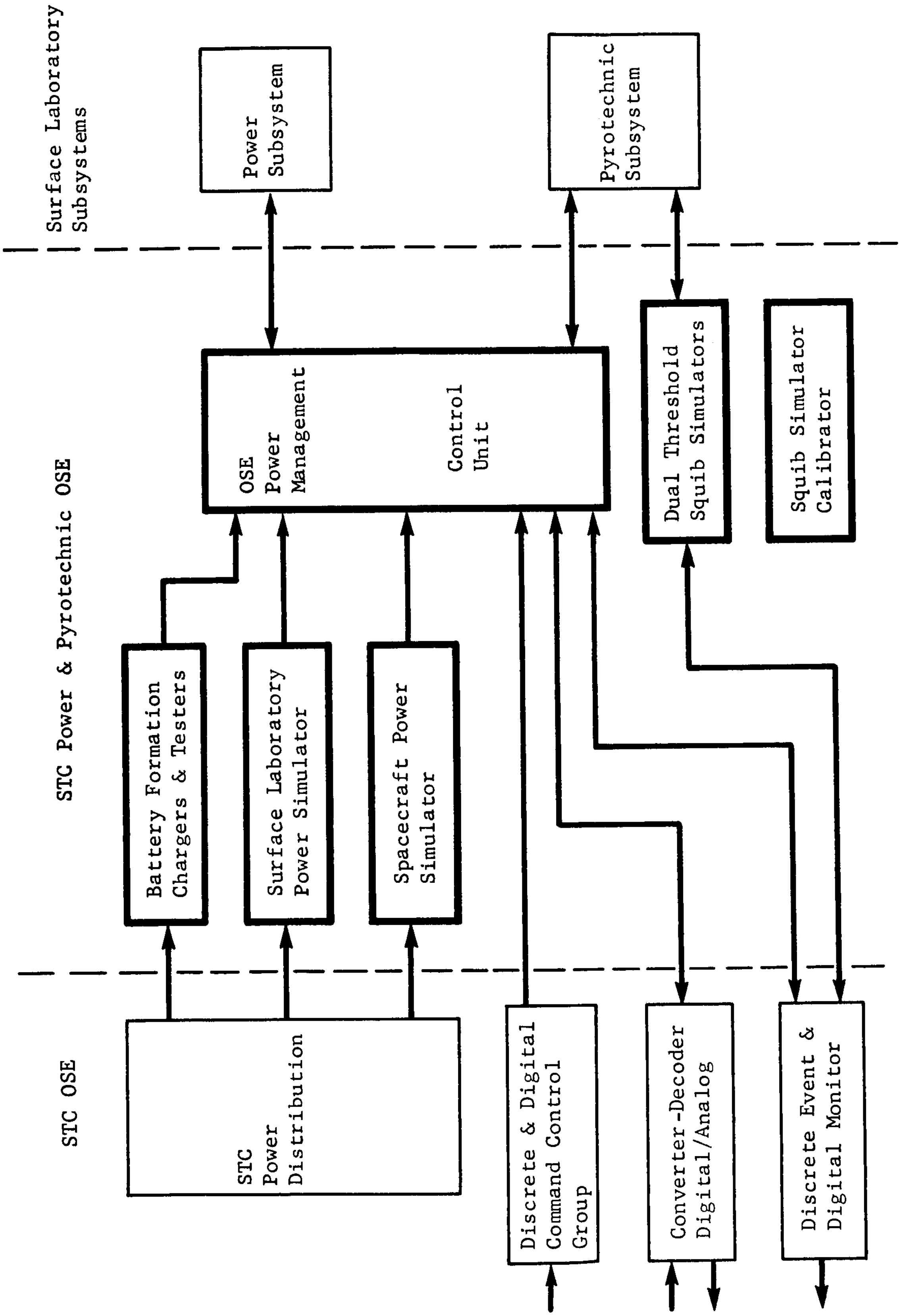


Fig. 3-10 STC Power and Pyrotechnic OSE

The STC power and pyrotechnic OSE consists of two racks of equipment.

Surface Laboratory STC, Command and Sequencing OSE - No special-purpose OSE is required in the STC to support and test the command and sequencing subsystem. All command and monitoring functions are performed by using the STC command and data acquisition equipment.

Surface Laboratory STC Telecommunications OSE - This equipment is discussed below.

Subsystem Definition - The STC telecommunications OSE in conjunction with the STC command and data acquisition equipment provide the ability to support and test the UHF and S-band communications, the telemetry subsystems, and MDE during subsystem installation and system testing in the STC (Fig. 3-11).

The STC telecommunications OSE provides:

1) RF test equipment hardware, and switching for measuring RF power and frequency and for analyzing frequency spectrums
2) An S-band receiver for receiving and detecting the RF signals to verify MDE and telemetry
3) A UHF receiver for receiving and detecting UHF for verification of telemetry
4) Both hardline and radiated RF links including test antennas
5) An encoder and S-band modulator for OSE self-test
6) An RF frequency converter
7) S-band and UHF test transmitters
8) Interface and control hardware for interface with the STC general-purpose command equipment
9) Function generators, noise generators, and standard test equipment as required for self-test of the STC OSE.

STC Landed Science OSE - This equipment is discussed below:

Subsystem Definition - The STC landed science OSE in conjunction with the STC command and data acquisition equipment provides the ability to support and test the landed science experiments during system test in the STC. Refer to Paragraph 2.4 for a functional description of the experiments and experiment subsystem OSE.

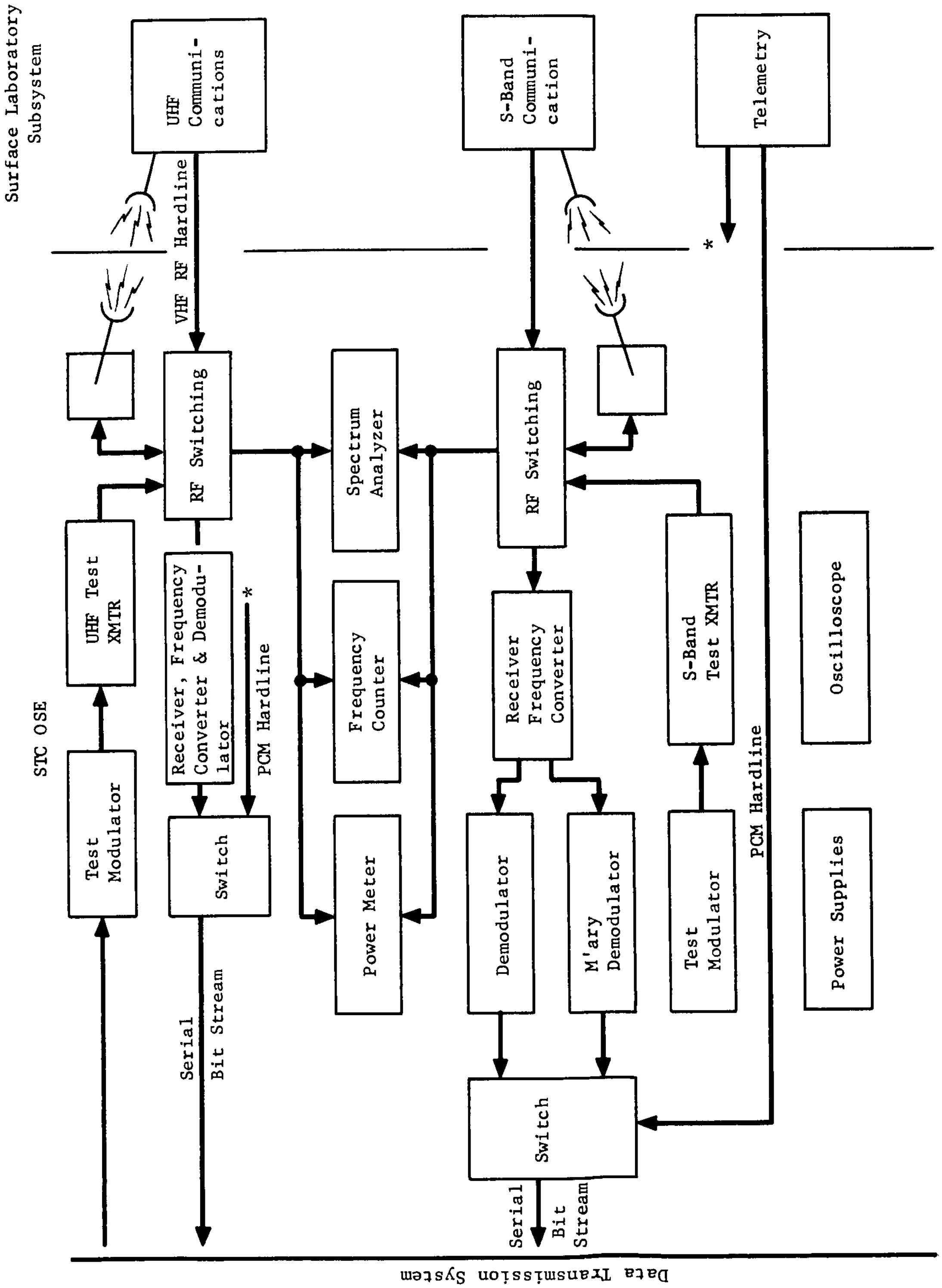


Fig. 3-11 STC Telecommunications OSE

Calibration equipment selected from subsystem OSE designs is used to simulate experiments in system level calibration. Acquisition of data for performance evaluation is accomplished with the general-purpose computer data-acquisition equipment. See Table 3-1 for preliminary testing methods.

Physical Characteristics - The STC landed science calibration and stimulus equipment is in a calibration cart. One OSE rack is provided for self-test and calibration equipment verification.

STC Structures and Mechanisms and Thermal Control OSE - No special-purpose OSE is required in the STC to support and test the structures and mechanisms and the thermal control subsystems. All command and monitoring functions are performed by the use of STC general-purpose command and data acquisition equipment.

3.2.2.4 Ancillary OSE

STC Power Distribution - The power distribution OSE is discussed below.

Subsystem Definition - The STC power distribution OSE distributes power to System Test Complex (STC) components and provides or controls grounding of the STC OSE and Surface Laboratory. Two power distribution groups are required for each System Test Complex. One group is in the control center; the other group in the vicinity of the Flight Capsule.

The STC power distribution equipment provides:

1) Receiving, monitoring, switching, switchover, distributing, interfacing, and controlling of power
2) AC-to-DC power conversion, isolation, switching, distributing, transient rejection, remote sensing, and interfacing of dc power
3) Circuit protective devices, disconnect mechanisms, interlocks, screening, and warning placards
4) Grounding (multipoint and single-point) and shielding consistent with specified requirements and generally recognized design practices
5) Interface with the digital command and monitoring STC OSE for power status display
6) Voltage and current metering and voltage adjustment of power supplies
7) Emergency power (batteries) and battery-charging capability.

Table 3-1 Preliminary STC Experiment Instrument Stimulus Methods End-to-End Testing

Experiments	Test Methods Stimulus
1. Visual Imaging Instrument (TV cameras & electronics)	a. Selected test patterns and movable targets to permit check of video & optical functions pre-encapsulation b. Video simulation
2. Molecular composition instrument (Gas chromatograph & mass spectrometer)	Stimulus of known gas samples injected into pneumatic inlet ports of the instrument Flush & recycle capability required Leakage rate detection required Servicing operations and vacuum pump required
3. Solids composition instrument (Alpha-scattering spectrometer & associated electronics)	Known material samples used Testing performed preinstallation of pyrotechnics Internal flight calibration pulser used in test Servicing operations & vacuum pump required
4. Solar insolation instrument	Known radiation provided by variable-intensity simulator illuminator Dark condition checked by installation of cap over instrument collector surface
5. Atmospheric Instrument (Mass spectrometer metabolism detector)	Controlled samples used Cleaning operations required
6. Metabolism Instrument (Mass spectrometer metabolism detector)	Controlled samples used Purging required
7. Biological Analyzer Instrument	Controlled samples used Purging required
8. Science Data System (Interface with all experiments)	Evaluated by normal flight sequencing & during all experiment end-to-end tests PCM monitored
9. Sample Acquisition & Processing System	Physical compatibility verified by performing all extensions & reversible functions Sequencing by flight sequence pre-encapsulation

Physical Characteristics - The STC power distribution equipment consists of approximately eight standard racks of equipment and the necessary interconnection wiring between STC OSE racks. The ac-to-dc power supplies are modular.

System Test Complex Voice Communications - The voice communication facilities are discussed below.

Subsystem Definition - The STC voice communication facilities provide:

1) Intercommunications connecting all operating positions in the STC and remote support areas (test conductor's console, Capsule-vicinity equipment, test areas)
2) Public address system (PA) in all STC test areas
3) Standard commercial telephones at the test conductor's console and other operating positions.

The space envelopes for communication equipment located in STC OSE remains identical for all STCs, although the amount of equipment used, and its source may differ at the Surface Laboratory contractor's facility, Spacecraft contractor's facility (PTM testing), and KSC.

Physical Characteristics - Each STC control center and remote test area has a communications distribution panel that serves the communications circuits in that area. Terminal intercommunications equipment is installed in all OSE consoles to provide communication between the test conductor and test personnel.

The communications distribution panel contains support hardware for the public address system, and interface provisions and patching for interfacing with launch operations at KSC.

Provisions are made for the location of telephones at test director's and test conductor's consoles and in other operator positions.

STC Time Distribution Unit - This unit is discussed below.

Subsystem Definition - The time distribution unit provides for receiving, isolating and distributing central, real, countdown, and internal times to the various STC components.

Physical Characteristics - The STC time distribution unit, located in the control center, consists of one standard rack of equipment.

Surface Laboratory STC Simulator Set - This set is discussed below.

Subsystem Definition - The Surface Laboratory STC simulator set is used to verify the integrity of the STC OSE before its connection to the flight article. It includes equipment required to simulate electrical interfaces with other flight systems during Surface Laboratory system tests.

The Surface Laboratory STC simulator set provides:

1) Ability to simulate Surface Laboratory power, signal data and RF interfaces over the entire permissible range of interfacing equipment tolerances.
2) Simulation of actual flight articles to permit testing STC OSE to verify that all STC checkout and test functions can be safely performed and that the STC can in no way damage a flight article.
3) Simulation of Surface Laboratory-Capsule Bus electrical interfaces
4) Simulation of Surface Laboratory-Spacecraft electrical interfaces.

Physical Characteristics - The Surface Laboratory STC simulator set consists of approximately two standard racks of equipment. In addition, the special-purpose subsystem OSE equipment described in Section 3.2.2.3 contains some hardware that serves dual functions of Surface Laboratory support and simulation, i.e., the Surface Laboratory power simulator, which is part of the power OSE support equipment. The discrete and analog stimulus generation equipment is used to generate checkout signals that are turned around and interfaced with the computer system data acquisition circuitry for STC OSE verification and self-test.

Data Transmission System - This system is discussed below.

Subsystem Definition - The data transmission system is required for transmitting commands and data between the Surface Laboratory-vicinity test equipment and control center equipment. For the most part, the transmission system is digital transmission links. Hardwire transmission links are provided to control emergency functions during STC test operations.

The Data Transmission System provides:

1) A digital system command uplink to convey stimulus, switching and control commands from the control center computer command I/O equipment to the Surface Laboratory-vicinity OSE

2) A digital system transmission link for conveying Surface Laboratory and OSE discrete and digital data from the Surface Laboratory-vicinity discrete event and digital monitoring equipment to the computer system.
3) A digital system transmission link for conveying Surface Laboratory-vicinity converter-decoder, digital/analog equipment to the computer system analog I/O equipment
4) Digital system transmission links for conveying telemetry PCM data received over hardlines from the Surface Laboratory and from Surface Laboratory-vicinity RF demodulators to the computer system PCM preprocessors
5) Hardlines for conveying emergency control and alarm monitoring signals
6) Modulating, demodulating, transmitting, receiving and reconstructing digital data as required
7) Interfacing with the STC timing system for clocking and synchronizing
8) Ability to transmit bilevel data trains of continuous information.

Physical Characteristics - The data transmission system is divided into four major types of components -- transmitters, receivers, coaxial transmission lines, and hardwires.

The transmitter and receivers are solid-state micrologic design and are mounted on printed circuit cards, approximately one card per transmitter or receiver. To provide efficient packaging, these cards are installed in the using equipment such as computer system I/O monitors, discrete and digital command control group, discrete and digital monitor.

Approximately five coaxial lines are required between the control center and the Surface Laboratory-vicinity area.

<u>Closed-Circuit TV</u> - the closed-circuit television system is discussed below.

Subsystem Definition - A closed-circuit TV system is provided for control center monitoring of the Surface Laboratory-vicinity operations during system testing.

Physical Characteristics - The closed-circuit TV equipment consists of two electronics equipment racks in the control center, plus monitors and the Surface Laboratory-vicinity cameras.

<u>Interconnection Racks</u> - The interconnection racks are discussed below.

Subsystem Definition - Interconnection racks are provided in the control center and at Capsule vicinity to provide interconnections and interfacing between flight systems and OSE.

Physical Characteristics - The interconnections are accomplished in two standard equipment racks.

3.2.2.5 Computer Programs

Use of a computer for checkout control and evaluation requires software that will allow the design and test engineers the maximum use of the system at all times. The computer data system (CDS) software is made up of three major components -- test language programs, supervisor/control programs, and offline operating programs.

Subsystem Definitions - The subsystem definitions are provided below:

1) Test language system - A set of individual computer programs for data monitoring and checkout operations. All CDS test and checkout procedures are implemented by an appropriate sequence of these test operations. A typical example of the 15 (approximate) elements is:

   The stimulate element is used to program the D/As that stimulate the vehicle analog input lines. Engineering units are included as a part of the level modifier as either volts or milliamps. The AND designator can be used to cause simultaneous application of stimulus.

   A special test language executive program allows the test conductor to execute any stored sequence or to construct a new test sequence. This program also provides for linking the test operations, auditing the test procedure and displaying the data and maintaining status.

2) Supervisory Program - control and service functions that do not require previously prepared data, parameters, or tables for their complete specification are provided by these computer routines. These computer programs provide supervisory function of:

   Initiation, coordination, and termination of status maintenance, test procedure, and internal system functions

   Initiation of scheduled and/or requested self-test routines

   Overseeing the loading and operation of all programable devices

   Communication among all CDS system computer programs

   Performance of safing and recovery routines and associated displays

   Printout of any operation originating at the test conductor's console other than data requests.

3) Off-Line Operating Systems - accomplish processing functions necessary to prepare procedures required for the on-line computer programs and perform further analysis of the data after completion.

The off-line software system assists in preparing and validating checkout procedures by translation, linkage and validation programs and by aids supplied for preparing tables and criteria. Symbolic references are to be established for procedures, data, and test points. A printout is supplied of any processed test language procedure.

The post-processing programs of the off-line software system provide for tabulation or plotting the data and extensive trend analysis. Analysis of such functions that cannot be performed in real time is also done by these programs. These may include the more extensive operations on TV or M'ary data.

Physical Characteristics - Programs of the computer data system are provided in the form of punched cards, or magnetic tape as applicable.

3.2.3 Description of Interfaces

The electrical and physical interfaces are listed below.

3.2.3.1 STC Electrical Interfaces

1) Facility ac power
2) IRIG and NASA 36-bit time codes
3) Facility countdown timing
4) Surface Laboratory bus direct access and umbilical connectors
5) Surface Laboratory hardline and open-loop RF interfaces
6) PCM hardlines
7) Spacecraft OSE (Surface Laboratory via Spacecraft umbilical)
8) Facility transducers
9) Flight cabling for simulation of nonreversible functions.

3.2.3.2 STC Physical Interfaces

a) Installation and assembly test areas
b) Thermal Vacuum Facility
c) Vibration and Acoustics Facilities
d) Flight qualification test areas
e) KSC installation, encapsulation and sterilization test areas
f) Planetary Vehicle test areas
g) Facility grounding systems
h) Internal AHSE interfaces.

3.3 System Analyses and Trade Studies

3.3.1 Trade Studies

Two trade studies were performed in the area of STC configuration definition -- System Test Complex Configuration Study, ED-22-6-52, and STC Computer System Selection, ED-22-6-57.

3.3.1.1 System Test Complex Configuration Study

The STC configuration trade study consists of analyses and studies of effects in each of the following areas:

1) Control center and Capsule-vicinity concepts concerning test control and display equipment location test philosophies
2) Implementation of manual control in the STC
3) Test control implementation in the STC
4) Data acquisition implementation for the computer data system
5) Use of subsystem OSE test sets in the STC versus an integrated system test philosophy
6) STC control center display and control capability
7) LCE considerations
8) MIE/MDE considerations
9) Facility design and location effects.

The conclusions of the individual analyses and studies are implemented in the preliminary STC design described in this report. A strong emphasis was placed on minimizing and moving direct interfacing equipment with the Flight Capsule system and on maximizing the use of the computer data system capabilities for control as well as data processing. Computer control is used to protect against operator errors as well as equipment failures.

Further refinements of STC design will be based on the results of additional studies as the Voyager program evolves.

3.3.1.2 STC Computer System Selection, ED-22-6-57

The recommended computer data system was selected as a result of evaluating several alternative systems. The following considerations were used as tradeoff factors in the selection:

1) Design for the decade
2) Capability for time and equipment sharing to minimize the number of computer systems required to support Capsule Bus, Surface Laboratory, and Flight Capsule tests within schedule and facility requirements

3) Cost effectiveness
4) Data acquisition requirements for a Capsule Bus, Surface Laboratory, and the integrated Flight Capsule
5) Computer bandwidth capabilities
6) Use of developed software test language to minimize software costs
7) Input/output equipment to more effectively use computer bandwidth
8) Logistics
9) Compatibility with STC display and control requirements
10) Space requirements
11) Reliability
12) Fixed computer systems at Denver and KSC versus movement of computer systems with Flight Capsules
13) Expansion capability.

A "third-generation" computer was selected to meet the requirements to design for the decade, and for expansion. The use of this system also allowed for greater processing speed and the ability to support more than one Capsule Bus, Surface Laboratory, or Flight Capsule with the accompanying reduction in computer cost. The greater processing power allows for fixed computer locations, both at contractor facilities and at KSC with reduced logistic cost of transportation of computers and reduced setup times. The system is designed so that optimum configurations can be established at a given contractor's facility or at KSC by adding or subtracting peripheral equipment such as I/O equipment, thus being cost-effective and at the same time maintaining identical software test languages and programing techniques.

In addition, the recommended system can use software languages and techniques developed for the Martin Marietta CAGE system, which performs identical functions for the Titan IIIM booster; therefore software costs can be minimized.

4. LAUNCH COMPLEX EQUIPMENT

The Launch Complex Equipment (LCE) comprises the Surface Laboratory Operational Support Equipment (OSE) in Launch Complex 39. The primary purpose of the LCE is to provide, with the support of the KSC STC and Capsule Bus LCE, for on-pad testing of Surface Laboratory Systems and to support all applicable prelaunch and launch operations.

4.1 Requirements and Constraints

With the STC Control Center OSE and Capsule Bus LCE, the Surface Laboratory LCE provides for complete testing of Surface Laboratory Systems, in accordance with JPL/NASA requirements and within these limits:

1) The planned Flight Capsule System launch pad operations are limited to monitoring the Flight Capsule System by in-flight status monitoring through Spacecraft data links and hardwired safety monitors
2) A capability is provided to perform a Flight Capsule integrity assurance test if some physical hazard has been encountered (shock, lightning). This test consists of a normal "in-flight" type checkout or specially programed test sequence performed by the onboard sequencing equipment. Command initiation, test program loading, and telemetry data monitoring is accomplished through normal mission preseparation data channels.
3) Except for hardwired safety control and monitoring, all flight system monitoring and testing is performed on Spacecraft raw power.

4.2 Preferred Preliminary Design

The preferred preliminary design is discussed in the following paragraphs.

4.2.1 System Definition

The preferred Surface Laboratory LCE configuration is shown in Fig. 4-1. The figure shows signal flow and location of the Surface Laboratory LCE required to support two Surface Laboratories. It also shows Capsule Bus LCE and indicates the supporting role of the Capsule Bus LCE in relation to the Surface Laboratory LCE requirements.

The ability to test and evaluate Flight Capsule Systems performance lies with the STC. The command capability to the onboard sequencing equipment and the flight systems TM data are available at the STC computer data system (CDS) through Spacecraft OSE. This interface between the CDS and Spacecraft OSE is established in STC planetary-vehicle-level testing and remains operational through prelaunch and launch activities. The hardwired flight systems safety control and monitor data, as well as LCE and pertinent facility data, are received by the CDS from mobile launcher LCE through wideband transmission links. The CDS operates on available data and displays them to subsystem specialists. The CDS also transmits summation status of the Surface Laboratory subsystem to the launch control center (LCC) for display on the Surface Laboratory test coordinator's console. The basic operation of the STC OSE, supporting LCE, is identical to established STC operations. This equipment is the central source for programing and initiation of the flight systems tests, acquisition and processing data, and evaluation of the flight systems and OSE performance. The only deviations from STC operations are the establishment of CDS/LCC data link and transfer of responsibility for the hardwired emergency safing of the Surface Laboratory Systems from the STC S/L test conductor to the LCC Surface Laboratory test coordinator.

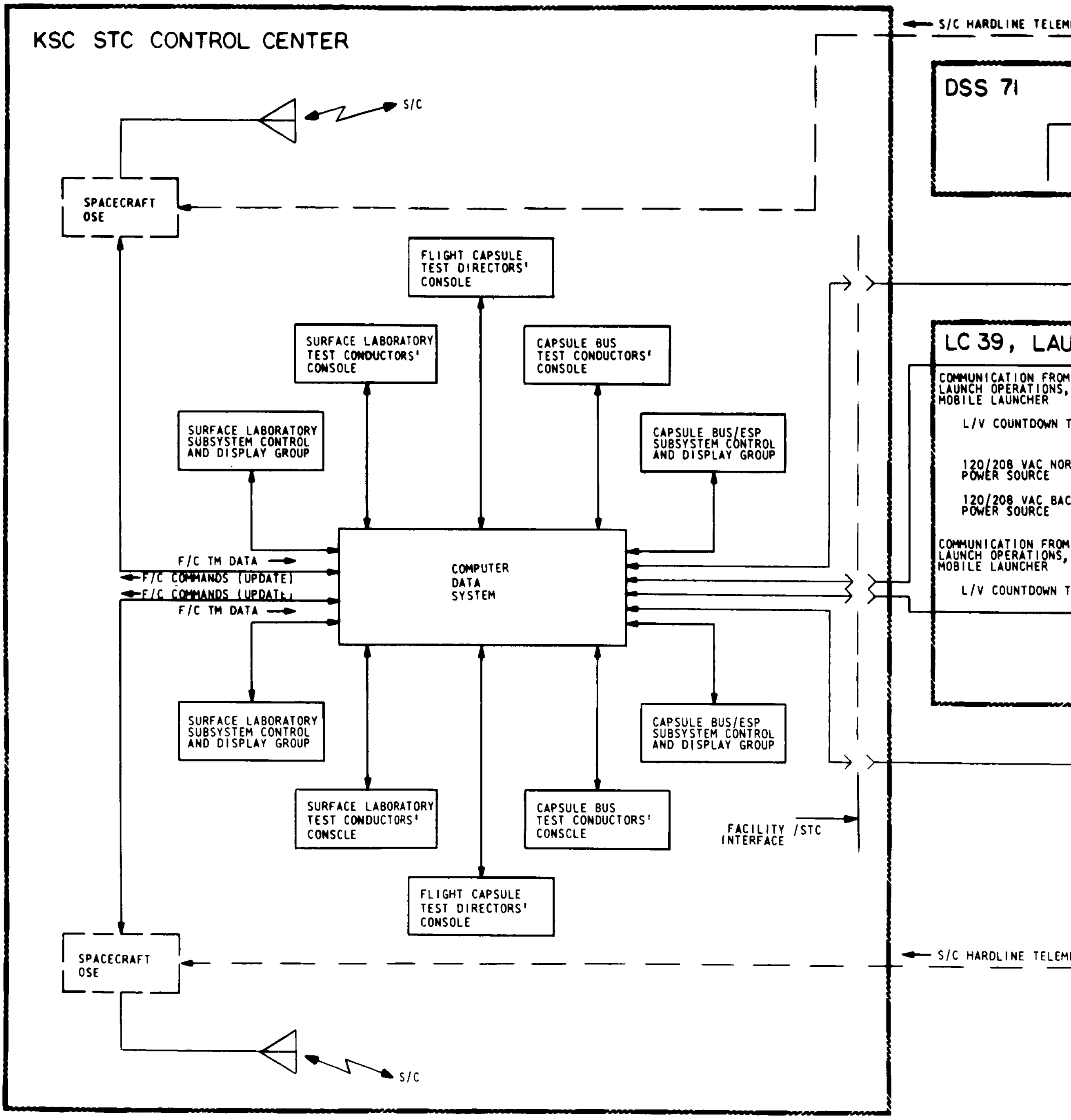
The integration of the Surface Laboratory Systems into the launch operation system is accomplished by the launch control center LCE. The launch control center LCE displays summation status of the Surface Laboratory subsystems and includes the ability to call up any additional data available in the computer data system (CDS). It also includes provision for hardwired, emergency safing and monitoring of the flight systems through mobile-launcher LCE.

The hardwired, safety control, and monitoring of flight systems is independent of the flight systems or facility power. The safing of the flight systems by the mobile launcher LCE is initiated either manually or automatically upon detection of hazardous conditions, e.g., safing of arm-safe devices. Parallel monitoring is employed in determining status of critical functions. A local evaluation, within the mobile launcher LCE, determines Go/No-Go condition of a critical function and transmits the results for display in the LCC. The second method employs processing of the safety functions and other pertinent data for transmission to the STC, where their exact limits are determined by the CDS.

4.2.2 Subsystem Characteristics

The Surface Laboratory LCE is illustrated in Fig. 4-2. It consists of the Surface Laboratory test coordinator console, two signal conditioning units, and two Surface Laboratory control and display chassis. The Surface Laboratory test coordinator's console is in the LCC; the remaining equipment is in the mobile launcher. The following paragraphs present functional and physical characteristics of individual units comprising the Surface Laboratory LCE.

4-3



KSC STC CONTROL CENTER
S/C
SPACECRAFT OSE
FLIGHT CAPSULE TEST DIRECTORS' CONSOLE
SURFACE LABORATORY TEST CONDUCTORS' CONSOLE
CAPSULE BUS TEST CONDUCTORS' CONSOLE
SURFACE LABORATORY SUBSYSTEM CONTROL AND DISPLAY GROUP
CAPSULE BUS/ESP SUBSYSTEM CONTROL AND DISPLAY GROUP
COMPUTER DATA SYSTEM
F/C TM DATA
F/C COMMANDS (UPDATE)
F/C COMMANDS (UPDATE)
F/C TM DATA
SURFACE LABORATORY SUBSYSTEM CONTROL AND DISPLAY GROUP
CAPSULE BUS/ESP SUBSYSTEM CONTROL AND DISPLAY GROUP
SURFACE LABORATORY TEST CONDUCTORS' CONSCLE
CAPSULE BUS TEST CONDUCTORS' CONSCLE
FACILITY /STC INTERFACE
FLIGHT CAPSULE TEST DIRECTORS' CONSOLE
SPACECRAFT OSE
S/C
S/C HARDLINE TELEM
DSS 71
LC 39, LAU
COMMUNICATION FROM LAUNCH OPERATIONS, MOBILE LAUNCHER
L/V COUNTDOWN T
120/208 VAC NOR POWER SOURCE
120/208 VAC BAC POWER SOURCE
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S/C HARDLINE TELEM

4-4-1

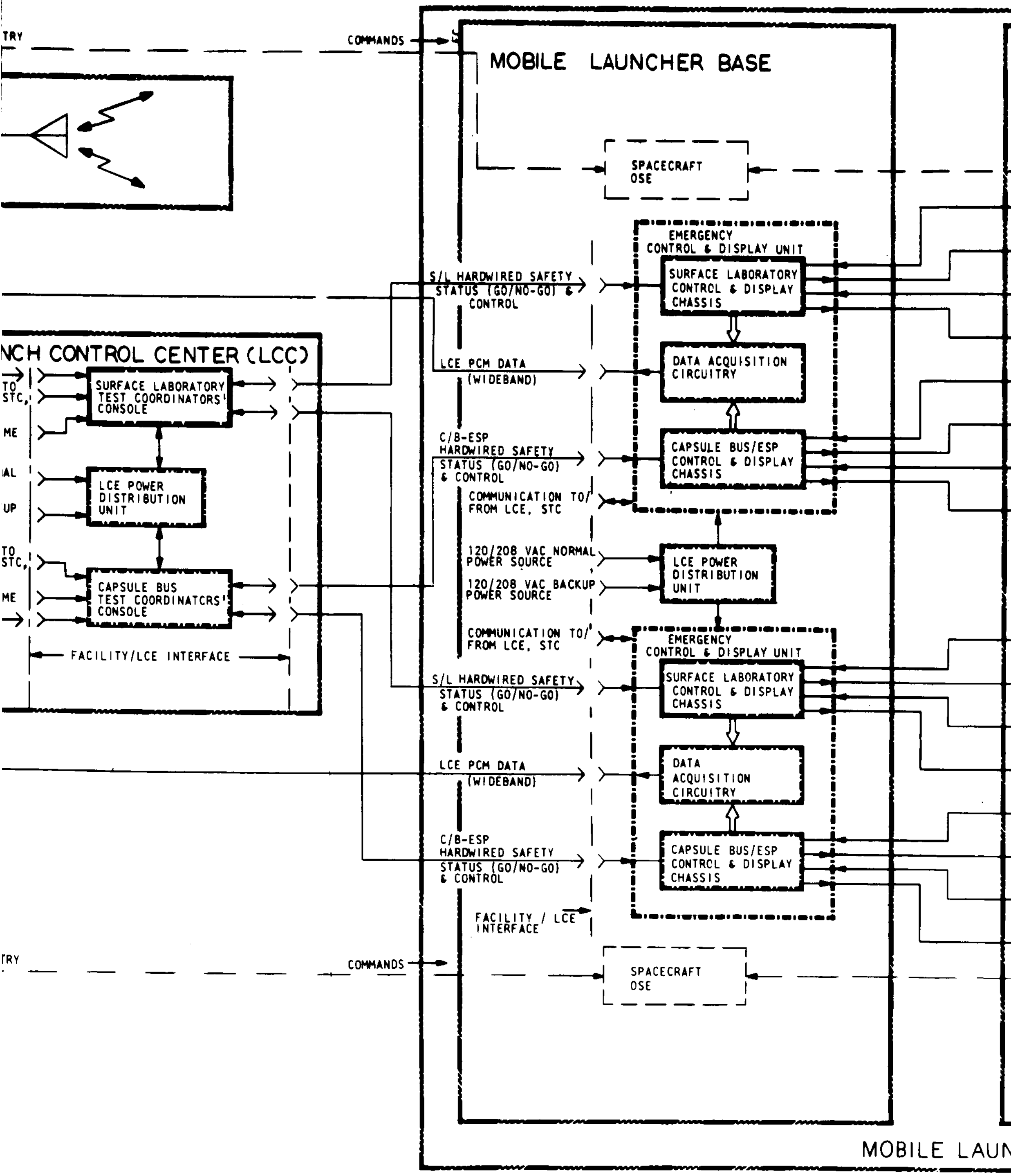
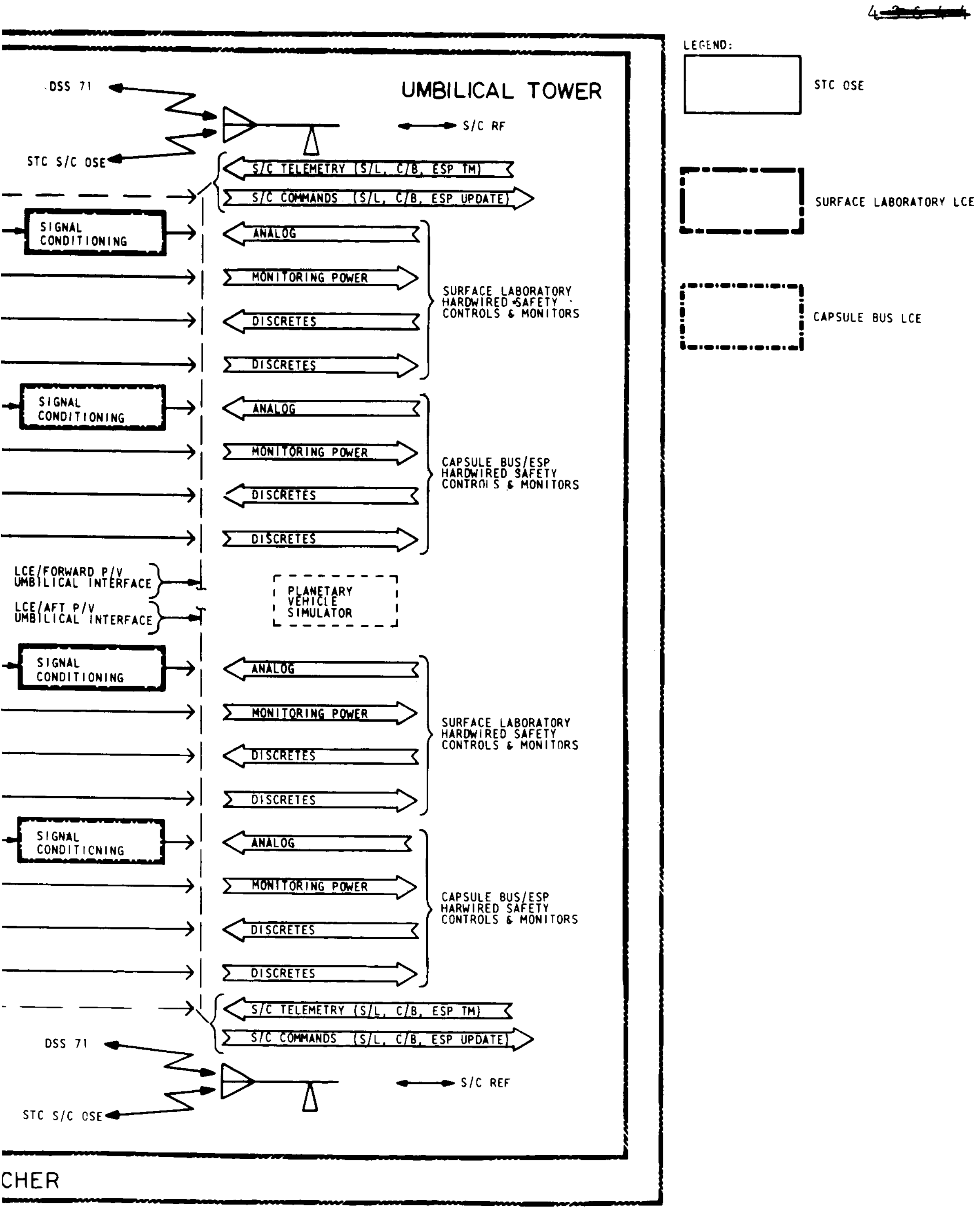


Fig. 4-1 LCE Configuration


UMBILICAL TOWER
DSS 71
STC S/C OSE
S/C RF
S/C TELEMETRY (S/L, C/B, ESP TM)
S/C COMMANDS (S/L, C/B, ESP UPDATE)
SIGNAL CONDITIONING
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
SURFACE LABORATORY HARDWIRED SAFETY CONTROLS & MONITORS
SIGNAL CONDITIONING
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
CAPSULE BUS/ESP HARDWIRED SAFETY CONTROLS & MONITORS
LCE/FORWARD P/V UMBILICAL INTERFACE
LCE/AFT P/V UMBILICAL INTERFACE
PLANETARY VEHICLE SIMULATOR
SIGNAL CONDITIONING
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
SURFACE LABORATORY HARDWIRED SAFETY CONTROLS & MONITORS
SIGNAL CONDITICNING
ANALOG
MONITORING POWER
DISCRETES
DISCRETES
CAPSULE BUS/ESP HARWIRED SAFETY CONTROLS & MONITORS
S/C TELEMETRY (S/L, C/B, ESP TM)
S/C COMMANDS (S/L, C/B, ESP UPDATE)
DSS 71
STC S/C OSE
S/C REF
CHER
LEGEND:
STC OSE
SURFACE LABORATORY LCE
CAPSULE BUS LCE

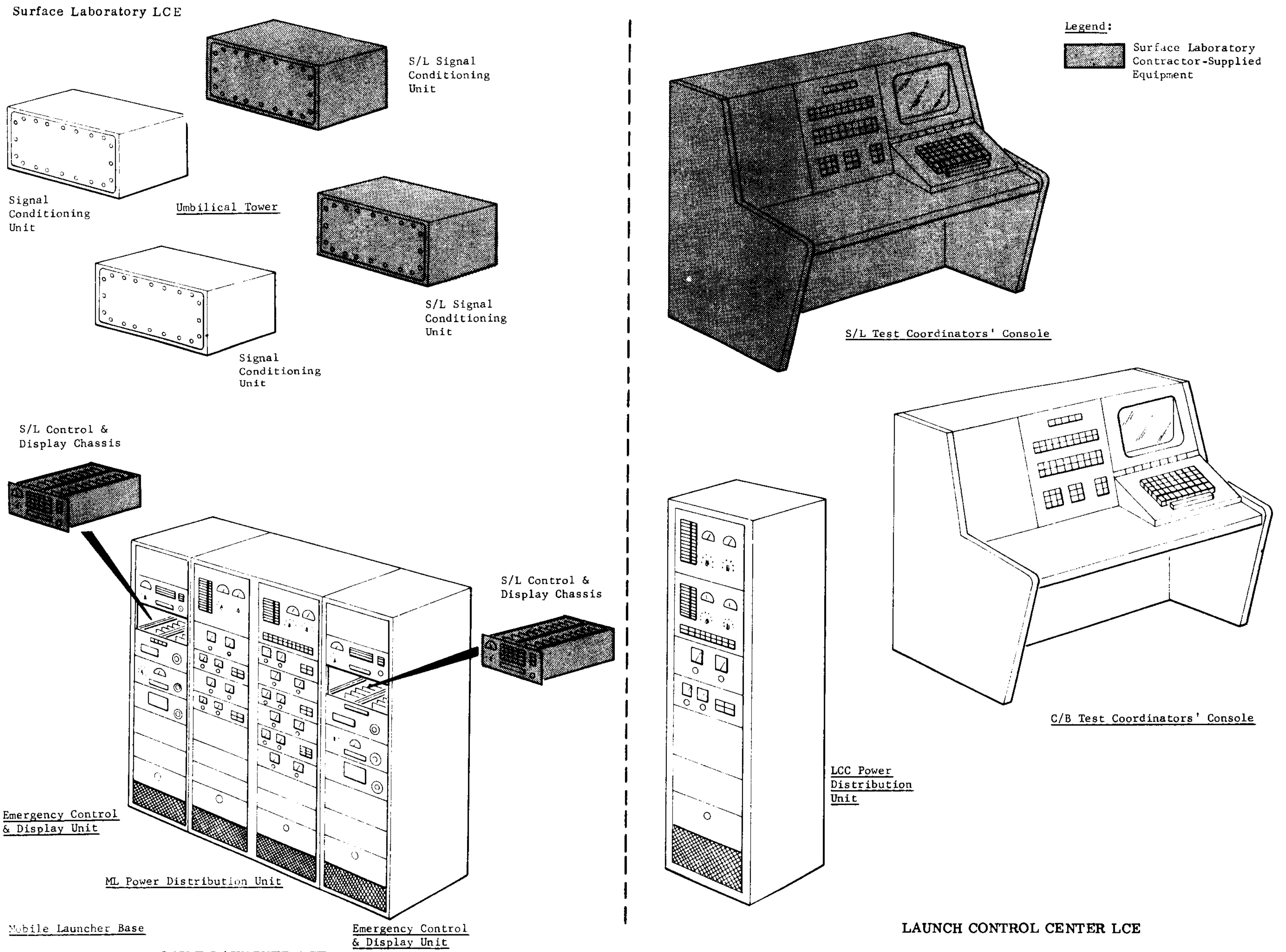


Fig. 4-2 Launch Control Equipment

4.2.2.1 Surface Laboratory Test Coordinator Console

Subsystem Definition - The Surface Laboratory test coordinator's console provides the man/machine interface required for integration of the Surface Laboratory Systems into the Launch Operations System. The console provides:

1) Display of Surface Laboratory Systems critical functions status, received from mobile launcher LCE
2) Display of LCE and facility status
3) Safing of Surface Laboratory Systems through mobile launcher LCE
4) Alpha-numeric display of Surface Laboratory subsystems summation status
5) Call-up ability for required Surface Laboratory data, available from the CDS
6) Voice communication with test and operations personnel
7) Display of launch vehicle countdown time.

Physical Characteristics - The Surface Laboratory test coordinator's console is a two-bay console containing switches, light indicators, a time readout, communication equipment, and a multipurpose keyboard display.

4.2.2.2 Surface Laboratory Control and Display

Subsystem Characteristics - In conjunction with Capsule Bus LCE, the Surface Laboratory control and display provides for hardwired safety control and monitoring of the Surface Laboratory, independent of flight system and facility power. It provides:

1) Monitoring of critical Surface Laboratory functions and automatic safing of Surface Laboratory on detection of hazardous conditions
2) Manual, local or remote, safing of Surface Laboratory
3) Automatic detection and local and remote display of Go and No-Go status of critical Surface Laboratory functions
4) Ability to locally display actual signal levels of all critical functions
5) Ability to locally or remotely initiate the self-test.

Physical Characteristics - The Surface Laboratory control and monitor is a standard electrical equipment chassis, 7x19x18 in., designed to be installed in the emergency control and display unit, provided by the Capsule Bus contractor.

4.2.2.3 Signal Conditioning Unit

Subsystem Definition - The signal conditioning unit provides any required amplification or conversion of the low-level umbilical signals necessary for their transmission from the Planetary Vehicle umbilical interface to the LCE at the base of the mobile launcher.

Physical Characteristics - The signal conditioning unit comprises signal amplifiers, converters, and power supplies housed in a weatherproof box designed for outdoor use.

4.2.3 Description of Interfaces

The Surface Laboratory LCE interfaces consist of functional interfaces with the Launch Complex 39 facility, STC, Spacecraft OSE, and Capsule Bus LCE.

4.2.3.1 Surface Laboratory LCE/Launch Complex 39 Facility Interfaces

The Surface Laboratory LCE/Launch Complex 39 facility functional interfaces comprise launch vehicle countdown time, transmission lines, and communication requirements.

Launch Vehicle Countdown Time - Launch vehicle countdown time is required at the test coordinator's console.

Transmission Lines - The following Surface Laboratory LCE transmission lines are required:

1) Two, two-wire, commercial quality, telephone lines between LCC and Flight Capsule STC for callup and display of Surface Laboratory data on the Surface Laboratory test coordinator's console
2) Limited number of hardwired lines between the LCC and mobile launcher LCE.

Communications - The Surface Laboratory LCE communication requirements are:

1) Connection of the voice communication equipment within the Surface Laboratory (S/L) test coordinator console into the Launch Complex 39 communication network
2) Access to Launch Complex 39 public address system at the LCC
3) Four voice communication channels are required, assigned as follows:
   a) S/L test coordinator - Voyager launch operation
   b) S/L test coordinator - Spacecraft operation
   c) S/L test coordinator - STC operation
   d) S/L test coordinator - All Capsule Bus LCE communication stations (Capsule Bus (C/B) LCE communication stations in the mobile launcher are shared by the C/B and S/L personnel).

4.2.3.2 Surface Laboratory LCE/STC Interfaces

The Surface Laboratory LCE/STC interfaces consist of operational requirements imposed on the STC in support of the Surface Laboratory LCE. These requirements are:

1) Provide complete control and monitoring of all Surface Laboratory launch pad operations, as provided for by LCE and flight system circuitry
2) Interface with the Spacecraft OSE for flight system telemetry processing and command capability
3) Interface with Capsule Bus LCE through facility transmission lines for processing mobile launcher LCE data
4) Provide processing, recording, distributing, and displaying of flight systems, OSE, and test facility data for real-time and nonreal-time analysis by the computer data system
5) Interface with Surface Laboratory test coordinator console through facility transmission lines to allow for call-up and display of Surface Laboratory Systems data in the launch control center.

4.2.3.3 Surface Laboratory LCE/Spacecraft OSE Interfaces

The Surface Laboratory LCE/Spacecraft OSE interfaces consist of operational support of the Surface Laboratory Systems by the Spacecraft OSE. This support is defined as:

1) Application of Spacecraft raw power to the Flight Capsule
2) Activation of the Spacecraft OSE for transmission of Flight Capsule telemetry data to the STC computer data system and transmission of the computer data system-generated commands to the Flight Capsule sequencing equipment.

4.2.3.4 Capsule Bus LCE/Surface Laboratory LCE Interfaces

The Capsule Bus LCE:

1) Provides ac and 28-vdc power to Surface Laboratory LCE
2) Conditions and transmits to the STC Surface Laboratory data available at the Mobile Launcher
3) Provides space and rack wiring for Surface Laboratory control and display chassis within emergency and control units.

4.3 System Analysis and Trade Studies

The preferred LCE configuration is a result of evaluation of the JPL/NASA Voyager Program requirements, Launch Complex 39 constraints, flight system configuration, and flight system checkout and test philosophy. The preferred LCE configuration is a cost-effective system that provides optimum service for all required prelaunch and launch operations. It also has a minimum effect on the Launch Complex 39 facilities, where space is at a premium. The extensive use of the STC has many important advantages. The Capsule Bus LCE activation task is simplified because only a small amount of equipment is installed at Launch Complex 39. The confidence in the mission success is increased through the use of the same equipment and continuity of testing, both of which support better data correlation and trend analysis.

The detailed analysis and tradeoffs leading to the selection of the preferred LCE configuration are presented in the Launch Complex Equipment Configuration Study, ED-22-6-55.

5. ASSEMBLY, HANDLING, AND SHIPPING EQUIPMENT (AHSE)

The AHSE includes the equipment necessary to lift, hold, position, align, assemble, test, transport, or store the Surface Laboratory in a safe and efficient manner.

5.1 Requirements and Constraints

Specific requirements for the various classifications or types of AHSE are described below. The basis of AHSE requirements is in SE003BB002-2A21, Voyager Capsule System Constraints and Requirements Document.

5.2 Preferred Preliminary Design

5.2.1 Shipping and Storage Equipment (Fig. 5-1)

The shipping container accommodates the assembled Surface Laboratory and provides shock and vibration absorbtion to safely cushion the package. It also provides an environmental atmosphere when the container is outside a controlled area.

Moving and Lifting Set (Fig. 5-1) - A handling truss, harness, and spreader-bar attachment is used to lift and position the Surface Laboratory. Attachment to the Surface Laboratory is at four points.

Positioner and Transfer Set (Fig. 5-1) - The Surface Laboratory subassemblies are handled by the components positioner, which is used for all assembly, disassembly, or servicing operations. This article of AHSE is common-use equipment.

Fixture Set (Fig. 5-2) - The support and safety fixtures set provides the necessary protection during installation and test of the deployable units.

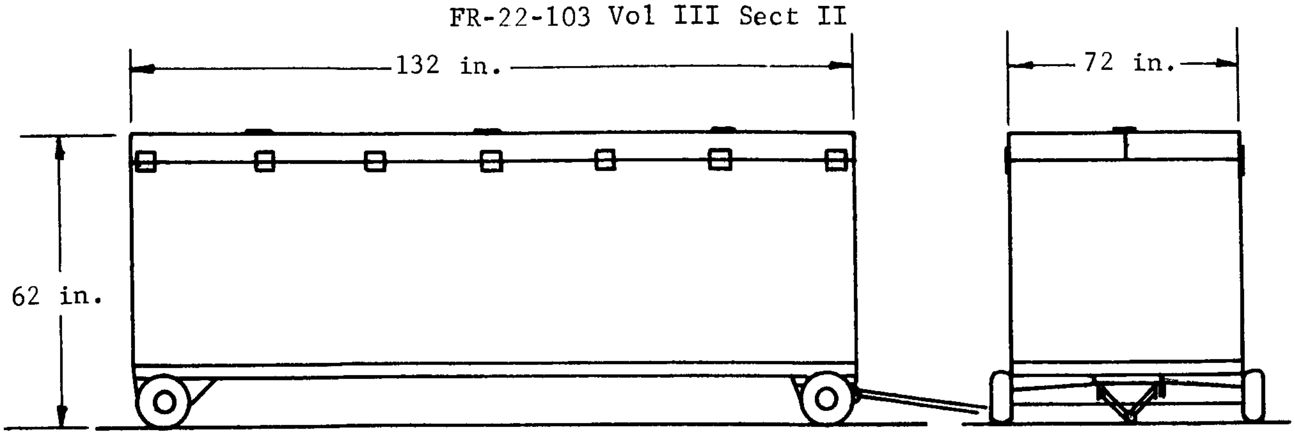
Vibration Table and Fixture Set (Fig. 5-2) - The universal vibration table is used to verify the integrity of components and the assembled Surface Laboratory. Adapters permit attachment of the assembly or components.

Platform Set (Fig. 5-2) - Platforms permit access during assembly, disassembly, and servicing and provide attachment of handling equipment.

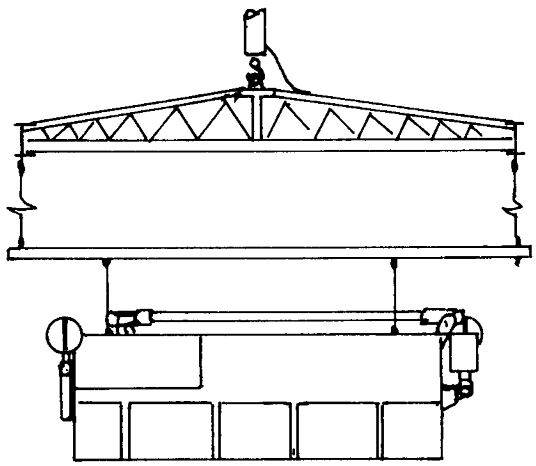
Special Tool Sets (Fig. 5-2) - Special tools required to install, service, or remove the subassemblies or the assembled Surface Laboratory are provided.

Cleaning Set (Fig. 5-2) - Cleaning equipment is also provided to permit adherence to the cleaning requirements in the subassembly and assembly areas.

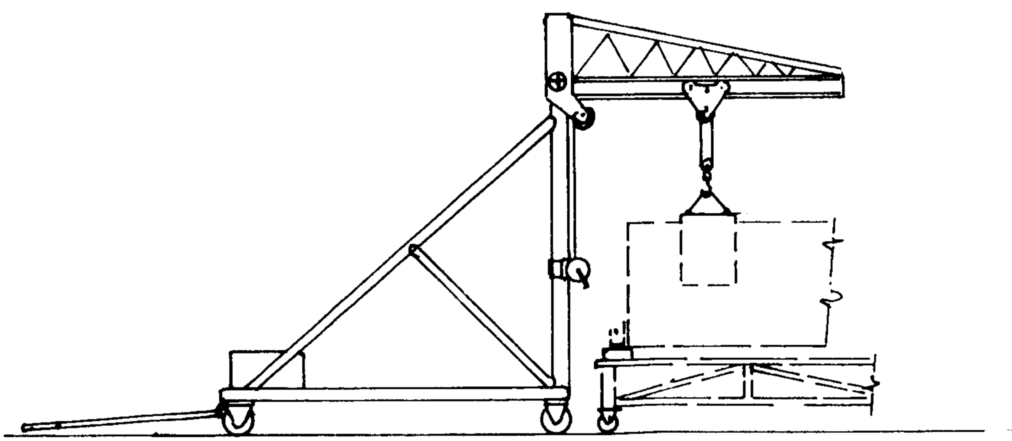
Weight and Center-of-Gravity Set (Fig. 5-2) - Weight and center of gravity are determined by the weight and center-of-gravity kit.



Surface Laboratory Protective Container



Moving & Lift Set



Component Positioner

Fig. 5-1 Surface Laboratory Assembly, Handling, and Shipping Equipment

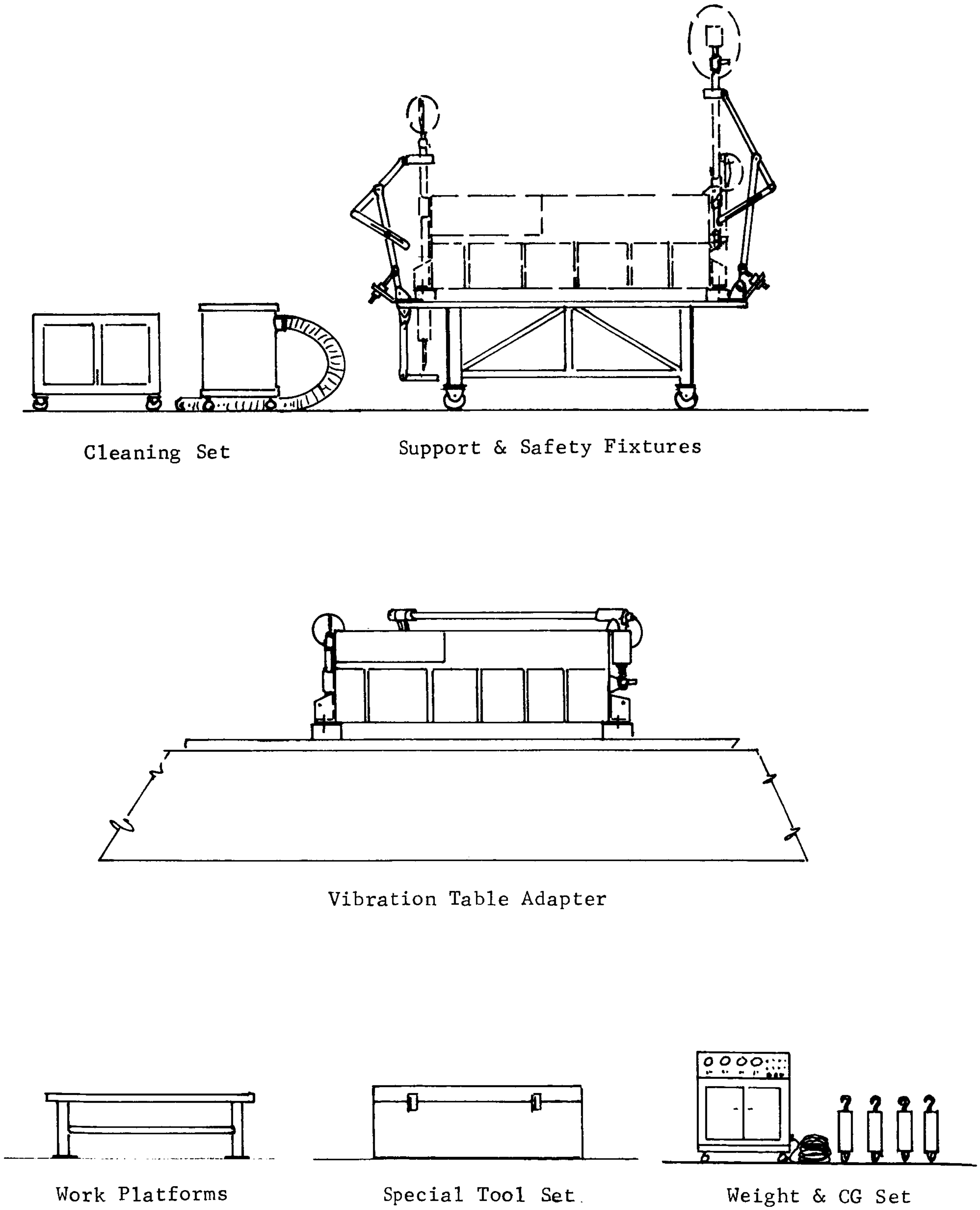


Fig. 5-2 Surface Laboratory Assembly, Handling, and Storage Equipment

5.2.2 Description of Interfaces

All AHSE that directly supports, lifts, handles, or contacts the Surface Laboratory will have coordinated attachments. Shipping interfaces, which include air, rail, or highway vehicles, will not create any unusual problems. Tie-down provisions will be provided on the shipping container, which will suffice for all modes of transportation.

5.3 Subsystem Analysis and Trade Studies

All selected AHSE associated with the Surface Laboratory has been coordinated with the specific use areas. Common use, compatibility between operations, and mobility have been incorporated in all applicable AHSE.

6.0 MISSION-DEPENDENT EQUIPMENT (MDE)

At the Deep Space Instrumentation Facility (DSIF) stations, and at the Space Flight Operations Facility (SFOF) the Deep Space Network supplied Mission-Independent Equipment (MIE) is capable of performing most of the telemetry and command functions. However, due to their uniqueness some Voyager mission functions require Mission Dependent Equipment. Figure 6-1 illustrates complete data links for the Deep Space Network functions and the MDE required to support the SL mission. MDE operates with the Mission Independent Equipment and mission-dependent software to accomplish required functions at the Deep Space Instrumentation Facility and Space Flight Operations Facility. The MDE is categorized as follows:

TYPE	LOCATION
Command MDE	DSIF
Telemetry processing MDE	DSIF
Radio simulator	DSIF
Television MDE	SFOF

6.1 DSIF MDE

6.1.1 Requirements and Constraints

The requirements of paragraph 1.0 of this section are applicable to the Surface Laboratory MDE. Additional design constraints are defined below.

To satisfy unique MDE constraints, the MDE design, with mission-dependent software:

1) Provides the required hardware for electrical compatilibity with the Deep Space Instrumentation Facility station equipment
2) Includes flexibility for expansion for multiple Surface Laboratory missions after the 1973 mission.

The initial selection and design of MDE components is consistent with providing the degree of reliability necessary to accomplish mission objectives. In providing the MDE to the Deep Space Instrumentation Facility sites, additional reliability considerations are satisfied:

1) Insofar as possible the MDE must have a history of operation gained from System Test Complex and Subsystem OSE use
2) All on-line equipment (i.e., command and data processing MDE) is fully redundant. Redundant data processing equipment is maintained on line; the command MDE is "block redundant," with the switching of warmed-up units manually or computer controlled.

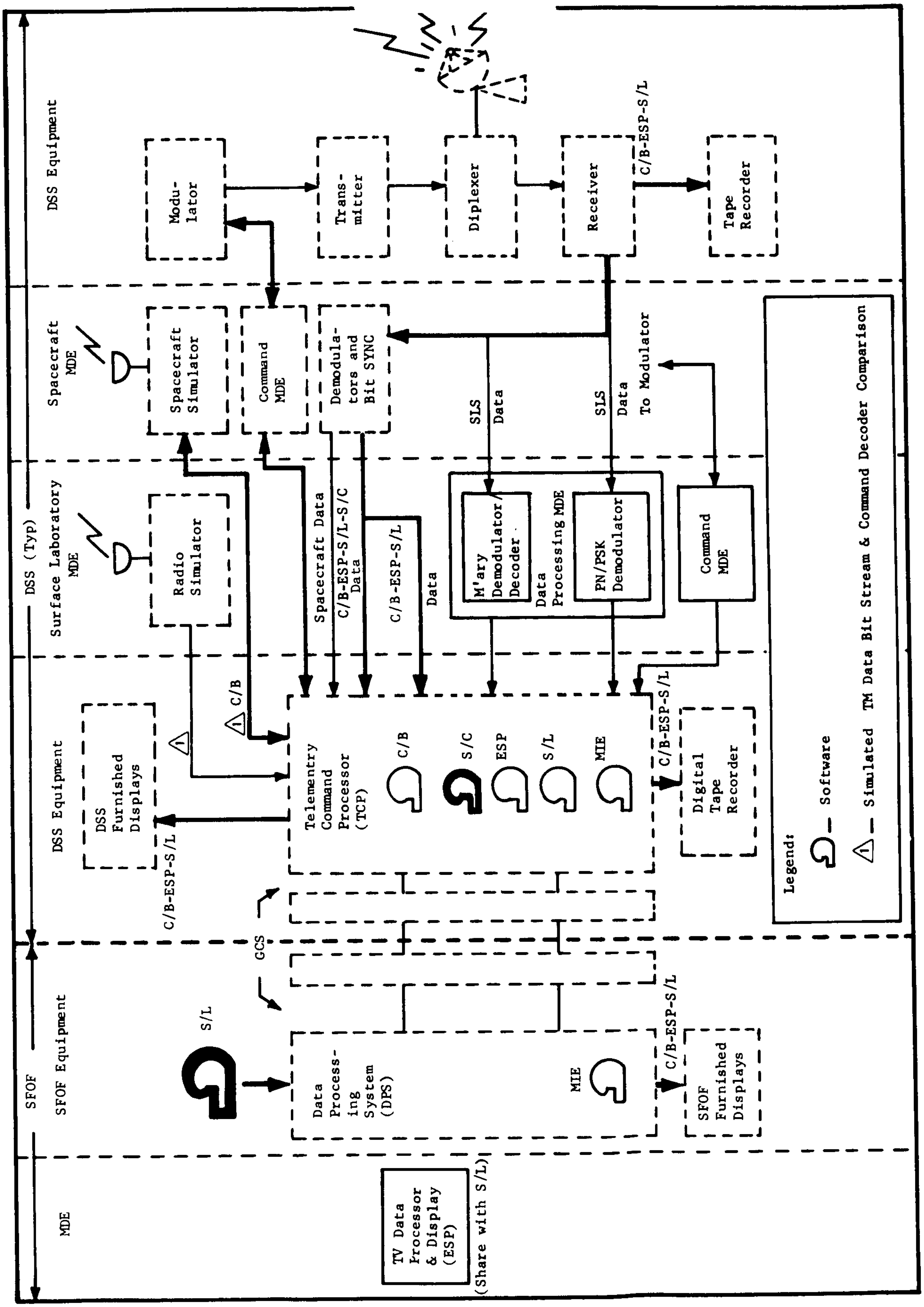


Fig. 6-1 Surface Laboratory MDE Implementation

3) A comprehensive test program is designed, and hardware and software supplied, for extensive testing of MDE with and independent of Deep Space Instrumentation Facility operations.

6.1.1.2 Required Functions

Overall - The primary (on-line) functions of the Surface Laboratory MDE are to provide:

1) Command signal modulation
2) Mission telemetry demodulation
3) Computer buffering.

In support of mission operations, the MDE provides:

1) Command detection for verification
2) Backup command encoding capability
3) Verification of DSIF/SLS compatibility
4) MDE evaluation testing
5) Support of Planetary Vehicle compatibility testing at the DSIF.

Data Processing MDE - The data processing MDE is designed to:

1) Receive the baseband PN/PSK telemetry data signal from the DSIF receiver
2) Detect the telemetry data bit stream
3) Receive and demodulate, using the MIE computer, the low data-rate M'ary-modulated signal
4) Transmit the telemetry bit streams to the MIE computers via the MDE computer buffer.

Command MDE - The command MDE is designed to:

1) Provide the pseudonoise code encoding of the telemetry and command processor signal.
2) Transmit the modulated command signal to the station transmitter
3) Provide a manual backup command encoding and transmitting mode.

Radio Simulator - In support of Deep Space Instrumentation Facility (DSIF) operations, the Surface Laboratory System radio simulator is designed to:

1) Provide the DSIF with a flight-equipment simulated signal
2) Accept the Mission-Independent Equipment simulated telemetry signals and modulate the S-band carrier
3) Support prototype/DSIF compatibility testing by simulating a second Planetary Vehicle
4) Receive and detect the DSIF transmitted command signal.

6.1.2 Functional Description

6.1.2.1 Data Processing MDE

Figure 6-2 is a block diagram of the data processing MDE, showing primary data paths. Operation of the data processing MDE is summarized below.

The high-data-rate telemetry transmission is received and phase demodulated by the DSIF station receiver; the baseband PN/PSK modulated signal is received by redundant MDE demodulator assemblies. A demodulator assembly consists of a subcarrier demodulator and bit synchronizer; the PN encoded pulse code modulated (PCM) data, with additive noise, is converted to a reconstructed nonreturn-to-zero (NRZ) bit stream. The demodulator assembly data output is buffered by MDE and transmitted to the DSIF computer for demultiplexing and display.

The demodulator assembly is designed to process any of the three data rates received in this mode of operation. Demodulator switching is MIE-computer or manually controlled.

In the Surface Laboratory System backup mode of operation each bit is translated into one of 32 discrete frequency variations (M'ary encoding) of the S-band carrier.

In this mode, the MDE receives the 10-MHz intermediate frequency signal from the Deep Space Instrumentation Facility receiver. The MDE contains an M'ary demodulator assembly to recover the telemetry bit stream through the use of autocorrelation and digital computation. In operation, the intermediate frequency output (from the filter) goes into the correlator where the autocorrelation function is read out through the demodulator buffer into the Mission-Independent Equipment (MIE) computer. The computer provides the filter and correlator controls and performs the Fourier analysis of the function to determine the received information frequency.

6.1.2.2 Command MDE

Figure 6-3 is a block diagram of the command MDE showing primary data paths. For normal mission operations, mission-dependent software will be provided for computer command initiation at the Deep Space Instrumentation Facility (DSIF) and Space Flight Operations Facility (SFOF).

The DSIF telemetry and command processor converts the instruction to the mission command format. The command signal is buffered and synced with the PN code by the MDE command modulator assembly.

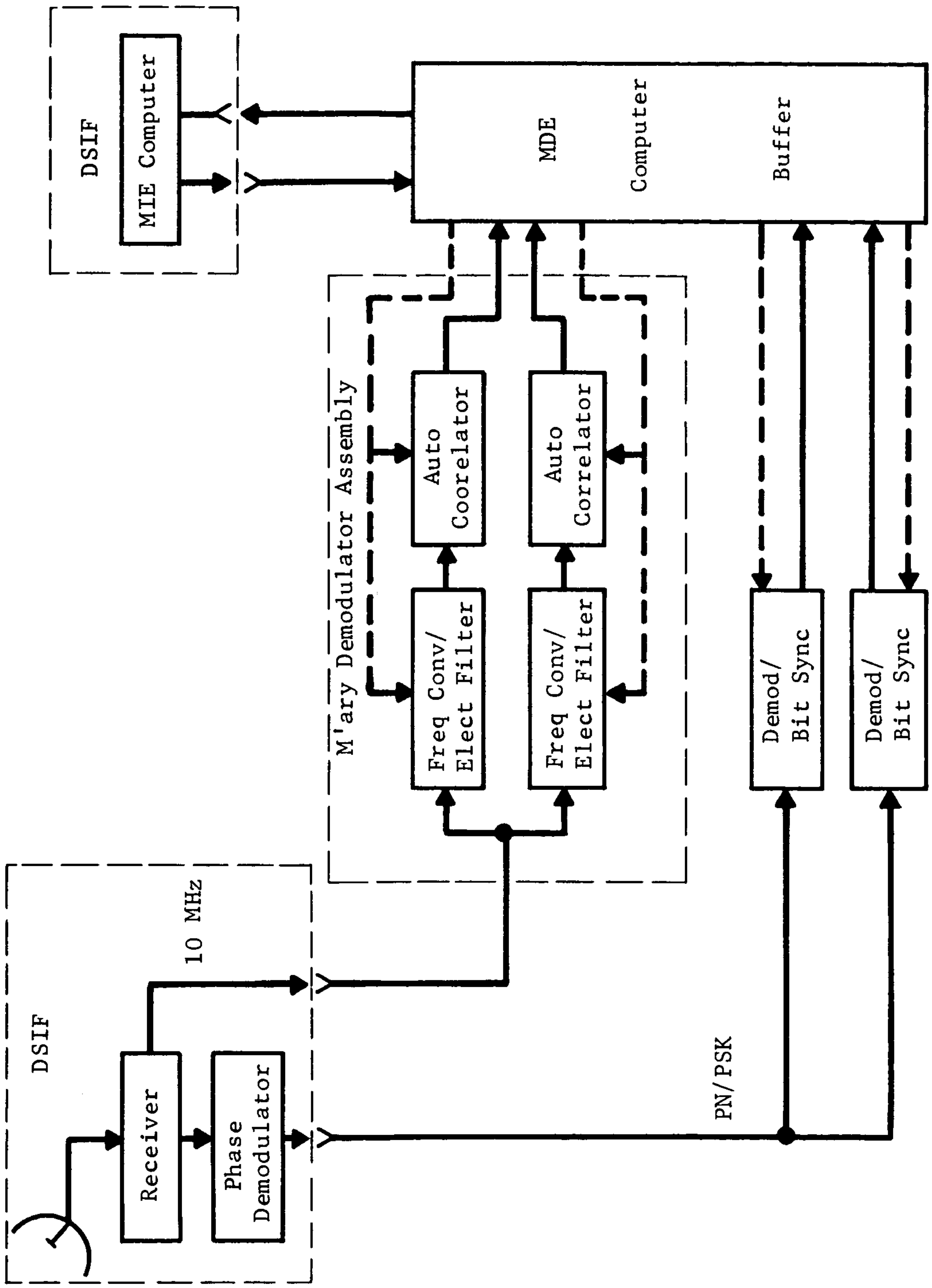


Fig. 6-2 Data Processing Mission-Dependent Equipment

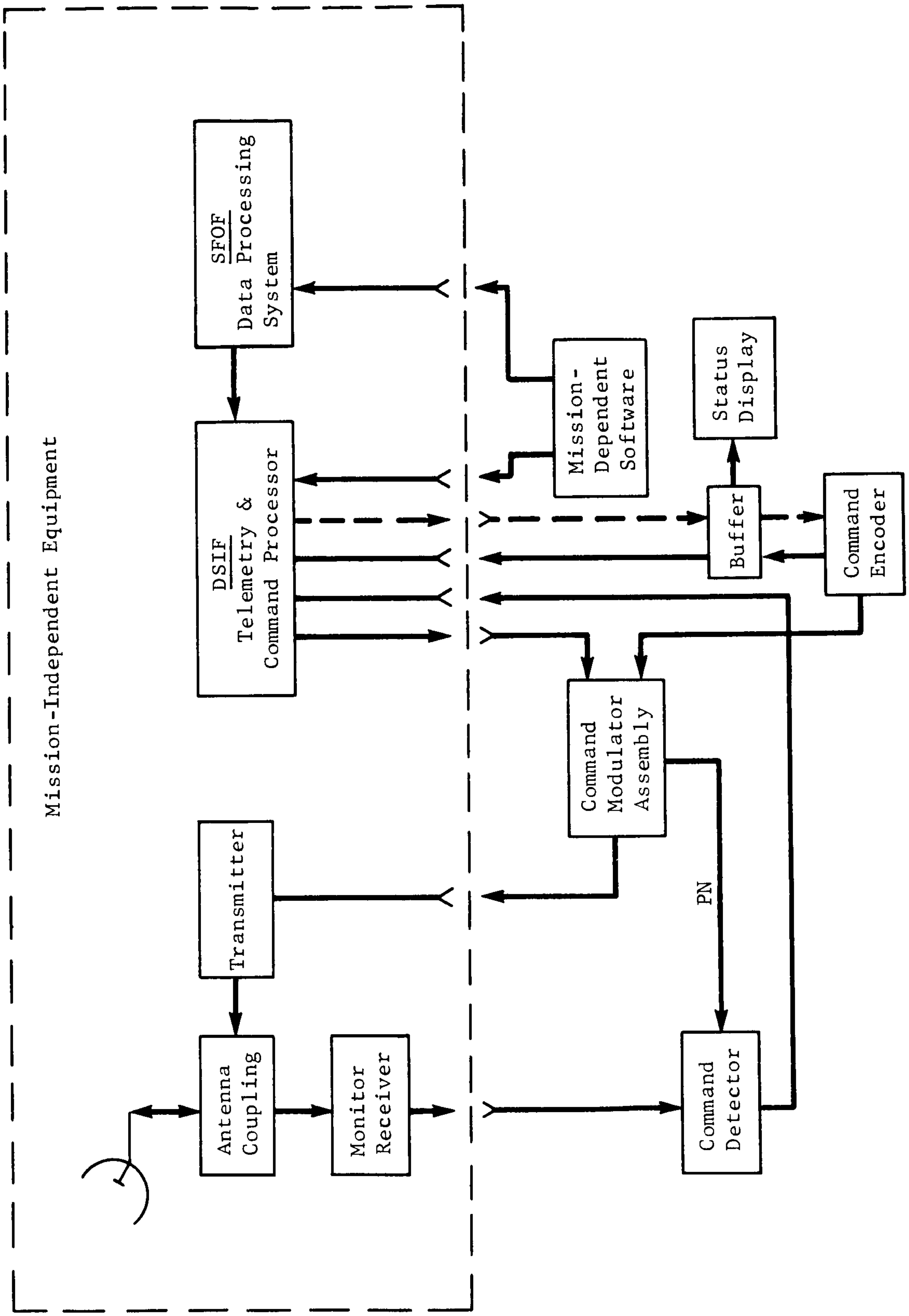
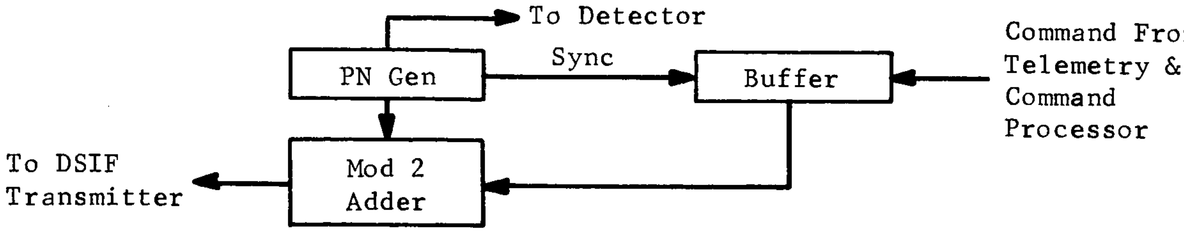


Fig. 6-3 Command Mission-Dependent Equipment

The command modulator assembly operates as shown and discussed below:



The command word is buffered within the modulator assembly; readout is initiated by the PN bit sync. The synchronized command word is then PN modulated and transmitted via the DSIF transmitter.

As part of the DSIF command verification procedures, the command being transmitted is sampled at the antenna and demodulated in the station monitor receiver. Detection is provided by the MDE command detector (Fig. 6-3); PN coding and bit sync are generated by the command modulator assembly.

For backup command capabilities, the command encoder permits manual initiation of commands independent of or using the computer processing and verification system. Digiswitches are positioned according to the desired format and the states transmitted to the storage register, which in turn actuates the command display. A buffered output is transmitted to the computer. Used with the computer, the command encoder transmission cannot be initiated until a computer-generated verification signal is received. For emergency operation, the command encoder transmits the command directly to the command modulator assembly without computer verification and authorization.

Command MDE is block redundant at the 100% level at DSIF sites.

6.1.2.3 Radio Simulator

The MDE radio simulator (Fig. 6-4) provides the required Surface Laboratory System (SLS) communications equipment for:

1) Verification of DSIF/SLS compatibility
2) Evaluation of MDE and MIE performance
3) Simulation of second Planetary Vehicle S-band signal for compatibility tests at DSIF.

For operation with the DSIF, the test transponder assembly receives the station S-band transmission, establishes coherency, and transmits at the SLS frequency.

The Mission-Independent Equipment (MIE) computer generates simulated telemetry data signals that are converted to Surface Laboratory System format in the MDE computer buffer. The MDE-PN/PSK modulator assembly pseudonoise encodes the signal, which is applied to the modulator-exciter and transmitted.

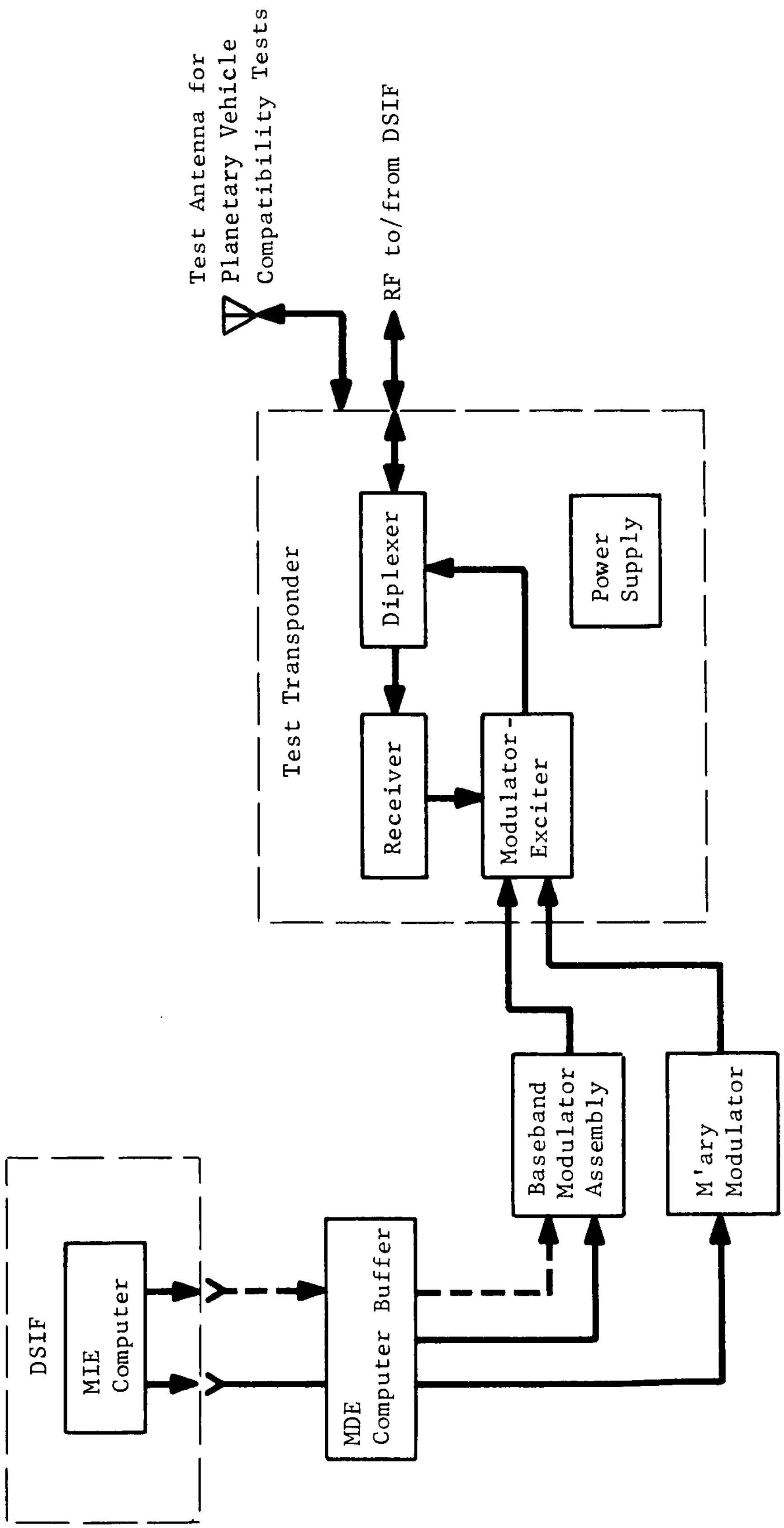


Fig. 6-4 Radio Simulator

The M'ary modulator receives parallel digital data from the buffer; the modulator converts the digital data to discrete frequencies and applies the signal to the test transponder modulator-exciter for transmission.

Two test transponder assemblies will be supplied to each applicable Deep Space Instrumentation Facility (DSIF) site; simulation of both Planetary Vehicles is required.

6.1.3 Physical Description

The MDE is designed to be compatible with DSIF facilities:

1) The MDE is mounted in standard JPL-DSIF racks
2) Primary power requirements are consistent with DSIF facilities
3) The MDE is designed to operate within the range of temperature and humidity encountered at the DSIF sites.

The test transponder assemblies are in portable suitcase-type containers that can be rack mounted. Power supplies are self-contained to accommodate remote operation in prototype testing.

6.1.4 Analyses and Trade Studies

Studies of the obtainable and desirable degree of dependency on the MIE are continuing.

In the MDE preliminary design presented in this section, functions performed by the MIE of the DSIF include:

1) All command verifications
2) Decommutation and display of high-data-rate telemetry
3) Digital demodulation, decoding, and display of emergency telemetry
4) Operational control of MDE switching functions
5) Control and signal simulation for MDE/DSIF test sequences.

The MIE computer system must be further analyzed for its capabilities and availability to perform all these functions. Tradeoffs in the areas of M'ary demodulation and transmitted command verification are required.

Presently, assuming the DSIF includes the equivalent of a sigma 5/7 computer capabilities for the 1973 mission, the station capability appears adequate to support the Surface Laboratory System mission to the degree presented, in addition to its other Voyager mission responsibilities.

other Voyager mission responsibilities.

6.2 Space Flight Operations Facility Mission-Dependent Equipment

This section describes the TV Mission-Dependent Equipment (MDE) supplied at the Space Flight Operations Facility (SFOF). The MDE receives digitized video data, processes them, and records on film and displays the resulting video picture. The TV MDE is also used for detailed post-mission video data analysis.

Fig. 6-1 illustrates the video data chain from reception at the Deep Space Station to display and recording at the SFOF. The Deep Space Station Telemetry and Command Processor decommutates the Spacecraft-relayed Entry Science Package and Surface Laboratory TV data, and formats them for transmission over the Ground Communications System from the deep space station to the SFOF. The SFOF computer decommutates the TV data and stores them on magnetic tape. At operator request, a complete frame of data is played back to the MDE for processing, display, and recording.

Table 6-1 lists the important Entry Science Package (ESP) and Surface Laboratory (S/L) TV camera parameters.

Table 6-1 Entry Science Package and Surface Laboratory TV Camera Parameters

	ESP		S/L	
	Camera A	Camera B	Camera A	Camera B
Vertical Limiting Resolution (TV Line)	200	200	140	140
Horizontal Limiting Resolution (TV Line)	200	200	166	166
Scan Lines	280	280	200	200
Field of View	18°	4.7°	97°/25° 6.5° Backup	16/4°
Data Output	Digital	Digital	Digital	Digital
Bits/Sample	6	6	6	6
Dynamic Range	60:1	60:1	60:1 Comp*	60:1 Comp
Linear Point Gamma	0.95	0.95	0.9	0.9

*Comp = Compressed

6.2.1 Requirements and Constraints

6.2.1.1 Constraints

The MDE that also performs functions included in the System Test Complex and subsystem OSE are identical to the hardware in those configurations. Mission-Dependent Equipment (MDE) uses standardized design whenever possible.

The design of the MDE ensures that no mission data are irretrievably lost as a result of MDE malfunction. This implies use of such techniques as raw data recording with provision for off-line playback and analysis.

To provide a high availability for mission use, the MDE must be designed for a long mean time between failures and a short mean time to repair. Self-check features are built into the equipment and redundancy techniques are employed for low-confidence items.

6.2.1.2 Functional Requirements

The TV MDE must be capable of:

1) Receiving digitized video data and control signals
2) Providing accurate records of the video picture
3) Providing an accurate display of the video picture
4) Providing a group display of the video picture
5) Providing a quick-look display of the video data
6) Quickly isolating malfunctions in its equipment
7) Providing or requesting image enhancement to each or every picture in the computer memory.

Transfer Characteristics - The display can reproduce the scene as it would be viewed by an observer in place of the television camera. This requires a unity system transfer function or unity gamma as shown in Fig. 6-5. The display must compensate for differences in camera transfer functions to produce unity system gamma. Varying the display transfer function results in image enhancement if the scene brightness is restricted to a portion of the dynamic range.

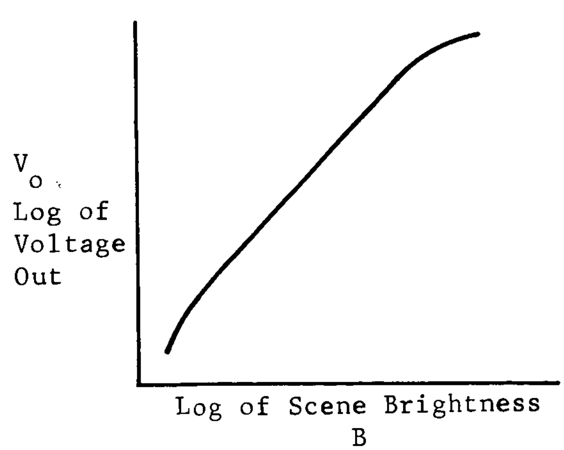


Fig. 6-5 Transfer Characteristic, Ideal System

Response - The display should not significantly degrade the system response in the horizontal or vertical directions (Table 6-1).

Dynamic Range - The dynamic range of the display should be as great as the system dynamic range (Table 6-1).

Geometric Distortion - Geometric distortion is the relative (geometric) element placement inaccuracy in the final photograph when referenced to the original scene. Geometric characteristics are obtained in subsystem test and used as data inputs for geometric correction subroutines.

Shading - For a uniform constant scene brightness, the output voltage of the vidicon will vary depending on the geometric coordinates of the sampled point. This effect is generally defined as shading. Shading characteristics are obtained in subsystem test and used as data inputs for shading correction subroutines.

Image Enhancement - Image enhancement is the intentional distortion of display or data characteristics to maximize the information transfer across the photograph-eye interface. The MDE display is capable of displaying image-enhanced data.

Other Display Requirements - Other display requirements include:

1) Display of picture identification data
2) Monitoring and status indications
3) Test pattern generator for calibration, checkout, and fault isolation.

6.2.2 Preferred Preliminary Design

6.2.2.1 Display System Definition

The display unit is a cathode ray tube and its associated electronics plus a film camera and processor (Fig. 6-6).

The control unit contains the timing and recognition circuitry for the display. This unit monitors and controls status of the other areas of the display.

The decommutator accepts 6-bit parallel bytes from the computer at approximately 100 kbps for Surface Laboratory TV data and inserts a 4-byte delay in the data stream to recognize Barker codes for frame sync, line sync, and identification (ID) data. After recognition of a particular Barker code, the pertinent controls and data are routed to using units in the following manner:

1) Identification data to the identification formatter
2) Video data to the digital-to-analog (D/A) conversion unit
3) Frame and line sync controls to the sync driver unit.

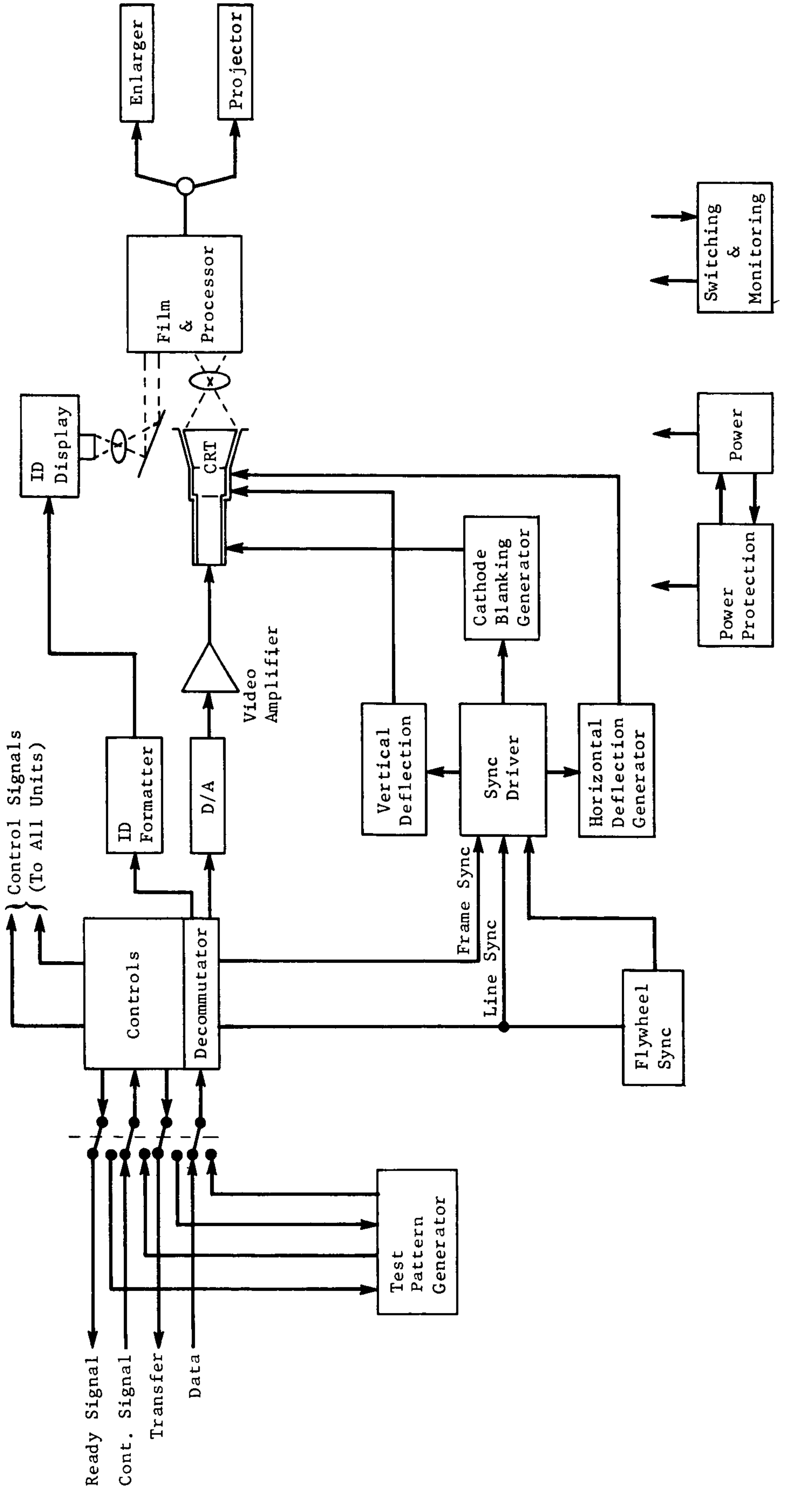


Fig. 6-6 MDE Display

The scan generation chain consists of a sync driver unit, flywheel sync unit, vertical and horizontal deflection generators, and a cathode blanking generator. The sync driver unit accepts frame and line sync control signals from the decommutator and generates gating and blanking signals for the deflection and blanking generators.

Correction signals are added to the vertical sawtooth to compensate for pincushion distortion and to destroy the raster effect by a high-frequency "spot wobble" superimposed on the composite wave form. The amplitude and frequency of the "spot wobble" are different for Entry Science Package TV and Surface Laboratory System TV data to compensate for differences in TV scan lines. Correction signals are also added to the horizontal sawtooth to compensate for pincushion distortion. The time constant is different for Entry Science Package and Surface Laboratory System TV data to compensate for differences in TV scan lines. The cathode blanking generator circuit supplies bias or cuts off bias from the CRT cathode on command from the sync driver unit. The cathode bias is enabled at all times during the display sequence except during horizontal retrace, vertical retrace, and power failures sensed by power protection circuits.

The identification (ID) data chain consists of an ID data formatter, and ID display unit and ID optics. The ID formatter accepts ID data from the decommutator and, based on control signals, formats and routes the data for use by the ID display. The ID display provides an alphanumeric display, formed by rear-projection read outs and letter masking, to make identification data a permanent portion of the video record. The ID optics demagnify and focus the ID display on a portion of the film unused by the video data. The video data chain consists of a digital-to-analog converter, video amplifier, CRT, lens, and film/film processor combination. A 6-bit digital-to-analog conversion is performed on command of the control unit; a video amplifier filters the converted digital signal and amplifies it to a level required by the CRT grid. The transfer function of the video amplifier is controlled by break points to achieve unity system point gamma and to compensate for compressed Spacecraft dynamic-range characteristic.

The CRT serves as an exposure source for recording the video data on film. A 5 in. flat-faced CRT with a centering coil, focus coil, deflection yoke and shielding is used. A lens with a magnification of less than one is used to transfer the information from the CRT to the film surface.

A small-area film (35mm) was chosen because of:

1) Availability
2) Adequate response and dynamic range
3) Enlargement equipment of reasonable size available
4) Projection equipment easy to obtain.

Film is processed by automatic equipment that is an integral part of the camera equipment. Automatic film advance after completion of a video frame is required. The film processing chemicals used, temperature of chemicals, and development times are closely controlled to maintain predetermined film-transfer characteristics.

Power supplies and protection circuits are required for logic power, CRT high voltage, CRT focus voltage, and video power.

The switching and monitoring panel provides test points for troubleshooting and monitoring functions and switching for manual or automatic (computer controlled) operation. A cathode ray oscilloscope is provided for test-point monitoring. A test pattern generator provides bar, resolution, and gray-scale patterns selected by the operator, and simulates the computer inputs and controls for Entry Science Package TV or Surface Laboratory System TV data.

There is an enlarger for photographic enlargement of negatives (It is intended that standard darkroom development techniques be employed). A projector is also supplied for projection of positives on a screen.

6.2.2.2 Physical Characteristics

The MDE is mounted in two standard racks plus a group-display projection console. Film processing facilities are also provided.

6.2.2.3 Interface Description

MDE/Computer - The computer provides for:

1) Control signals (from computer) to start the display process plus the signals required to mate display characteristics with vidicon characteristics (e.g., transfer function, scan lines, dynamic range)
2) Ready signals (to computer) to indicate that the display is ready to receive data
3) Request signals (to computer) for calling up particular TV frames from computer memory and specifying the type of image enhancement required on these data (if under computer control).

MDE/Observers - The observers provide:

1) Film and enlarged negatives
2) Film and enlarged positives
3) Polaroid pictures
4) Projected view of negative and positive.

6.2.3 System Analysis and Trade Studies

6.2.3.1 Preferred Approach

Three concepts for the display and recording of the video were considered in detail and are discussed below. A comparison of pertinent parameters is given in Table 6-2.

With the display and recording system discussed, the video data are stored on magnetic tape until a complete frame is received. On playback, the video data and control signals are routed from the Space Flight Operations Facility computer to the MDE for decommutation. A CRT/35 mm film recorder, with automatic film processing, is the basic display device.

This approach was chosen for several reasons:

1) Adaptability to use in the STC and Subsystem OSE
2) Full dynamic range using CRT pulsed beam technique
3) Full resolution capability
4) Minimum software and computer capacity requirements
5) Flexibility to compensate for differences in TV parameters
6) Sufficient reproduction quality for post-processing applications.

Scan Converter Tubes - Use of a scan converter tube requires, in addition to time buffering, periodic rewriting of the video information. Resulting disadvantages of this and other characteristics are shown in the Table 6-2.

Significant disadvantages are:

1) Dynamic range inadequate
2) Only low quality pictures possible
3) More electrically and mechanically complex
4) Post-processing applications limited.

A minor advantage is the time gained by presenting the display on a monitor.

Computerized Rate Conversion - The method was considered in which rate conversion would be performed by the Space Flight Operations Facility Computer and digitized video continuously read into the monitor. Although this operation is feasible for this type of picture, the computer would be providing data to the Mission-Dependent Equipment continuously, and time sharing might not be possible.

Table 6-2 Comparison of Alternative Display Concepts

Parameter	CRT Recorder	Scan Converter Tube	Computer Scan Conversion
Dynamic range	35:1 100:1 (pulsed beam)	12:1	35:1 100:1 (pulsed beam)
Unity transfer function	Yes	Yes	Yes (Computerized)
Limiting Resolution	2000 TV lines	1200 TV lines	2000 TV lines
Photograph	Yes	No	No
Monitor	No	Yes	Yes
Time available from receipt of frame	<15 min	<1 min	<2 min
Use as OSE Subsystem	Yes	Partial	No
Use as STC	Yes	Partial	Yes
Computer size	small (time shared)	small (time shared)	medium (full time)
Software rating	1	2	3
Display equipment size and complexity rating	2	3	1
Use in Post-processing applications	Yes	No	Yes

This consideration caused a rejection of this concept for on-line operation; however, it is similar to operating modes anticipated for off-line processing.

6.2.3.2 Redundancy Considerations

Redundant displays for the Space Flight Operation Facility are recommended for the following reasons:

1) Increased reliability, both displays are run in parallel
2) Flexibility, one display can take a positive while the other can take a negative photograph giving both enlargement and projection capabilities during the same data run.

Even though the preferred approach has no inherent monitoring ability, this is possible. The resulting photograph can be scanned at commercial rates and the video transmitted to monitors at the Space Flight Operations Facility on a closed circuit.

The video can also be transmitted to nationwide TV. In these cases, rapid development techniques on one of the redundant display MDE, or a parallel display, would present a slightly degraded but usable photograph shortly after reception of a complete video frame.